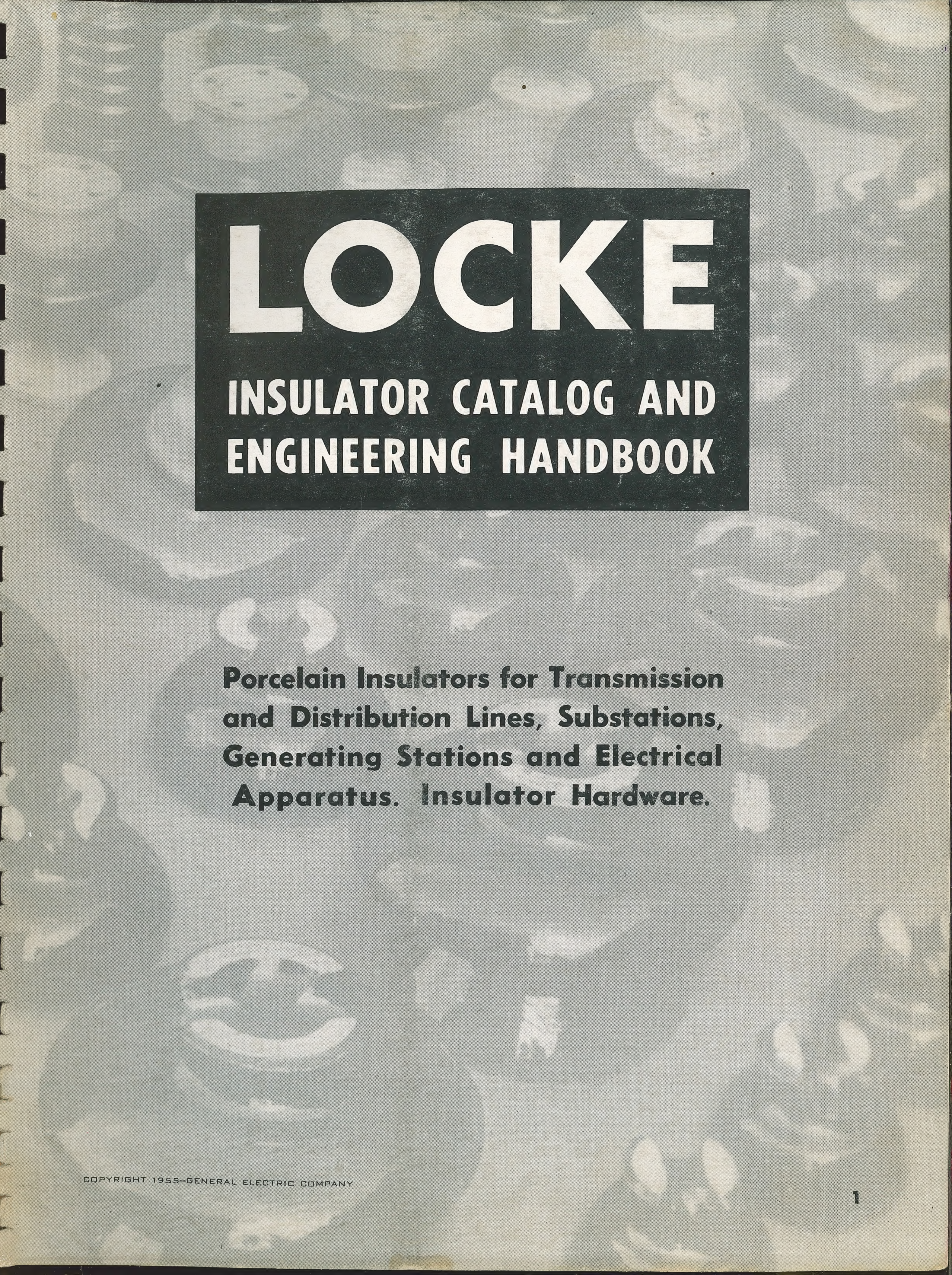
LOCKE

INSULATOR CATALOG & ENGINEERING HANDBOOK

NO. 55

LOCKE DEPARTMENT • GENERAL ELECTRIC COMPANY • BALTIMORE, MARYLAND



LOCKE

INSULATOR CATALOG AND ENGINEERING HANDBOOK

Porcelain Insulators for Transmission and Distribution Lines, Substations, Generating Stations and Electrical Apparatus. Insulator Hardware.

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How to use this

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is printed on the outer margin of each right page in this catalog. In each of the eleven sections of the catalog, the guide marks are printed at a different distance from the top of the page. Their location corresponds to the location of the name of each section on this index page.

To locate a desired section:

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2. Place the thumb of the right hand on the guide mark opposite the listing of the desired section on this index page.

This will open the catalog at the beginning of the desired section.

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SERVICE TO THE POWER INDUSTRY FOR 63 YEARS

Only sixty years ago, the development of electric power was in danger of being stifled. The need for higher transmission line voltages was apparent, but good insulators for such higher voltages were lacking.

During this almost stagnant period of electrical power development, a telegrapher in upstate New York was constantly annoyed by the failure of his telegraph circuits. He traced the trouble to his ceramic telegraph line insulators. The material used was porous and weak. It absorbed water in wet weather and permitted currents to leak through the insulator to ground via the wooden telegraph pole.

The telegrapher, Fred M. Locke, began to search for a better insulating material. Adapting materials widely used to make chinaware, he developed a wet-process method of making porcelain transmission insulators. This wet-process porcelain proved to be an ideal electrical insulating material not only for communication circuits but was quickly adapted to high voltage power transmission.

Thus, in 1892, Fred M. Locke established the Locke Insulator Company near Victor, N. Y.

for the first manufacture of wet-process electrical insulators. His products were soon accepted by the power companies who were the ancestors of today's great transmission systems. Years later, in 1920, the company became affiliated with, and in 1951 a department of General Electric Company. In 1922, Locke moved to improved facilities in Baltimore, Maryland.

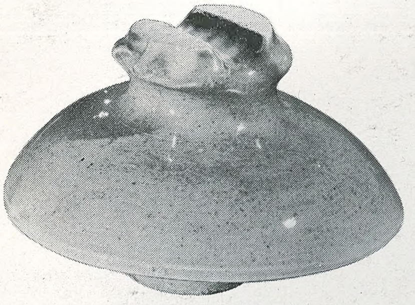
The pioneering spirit of Fred M. Locke has been carried on by Locke management and employees for over sixty years. The quest for high quality insulators at economical cost resulted in many progressive achievements. It was realized many years ago that the successful manufacture of quality insulators is dependent on scientific selection and proportioning of ingredients, the employment of proven processes, and, most of all, exact factory control. Every step in the manufacture of a porcelain insulator has some bearing upon the final product. Irregular treatment of the ware, as it passes through the various phases of manufacture, has to be avoided.

Today, at Locke, one of man's oldest arts is combined with modern techniques. The materials flow through intricate machines and conveyor lines. They are brought to white heat in long kilns and emerge as glistening insulators, moving through fingers of crackling sparks in the final electrical tests. At each production step, uncompromising quality control assures uniformity of the finished products and years of uninterrupted service. They go on to join the thousands of Locke insulators—from tiny switch parts to giant bushings—which are serving as safe, dependable units of high voltage power transmission and distribution systems throughout the world.

The original Locke plant at Victor, N. Y., where Fred M. Locke made the first wet-process porcelain insulators before 1892.

LOCKE PORCELAIN INSULATORS

INSULATOR

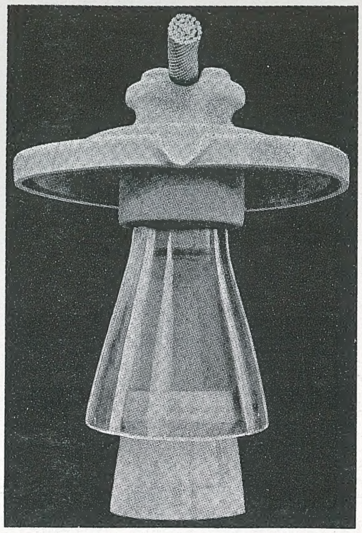


This Locke Pin Type Insulator, after 47 years of service in South Dakota, is still good for re-use.

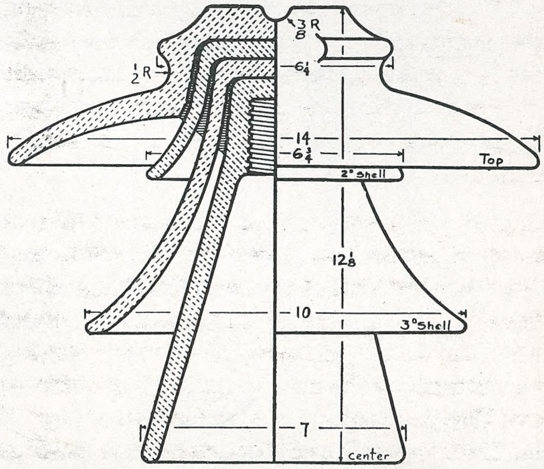
PIN TYPE INSULATORS

The earliest wet-process porcelain insulators were of the pin type. It was natural that the first alternating current transmission and distribution lines should adopt the overhead pole line construction, with the conductors mounted rigidly on pin type insulators above the crossarms. This practice had been used in the lower voltage DC lines and in telegraph lines. In general, the earliest wet-process porcelain pin type insulators consisted of single-piece units, similar in construction and details to glass insulators which had previously been used. As the need for high voltages grew rapidly, the requirements for striking distance and dielectric strength of these insulators increased. Soon, one-piece units became impractical to perform the insulating function adequately and multipart insulators were devised. The first multipart insulators were made by fusing two or more elementary insulator shells together, employing glaze which would flux at the firing temperature and fuse the several parts together into a single integral unit. It was soon found, however, that these units were so rigidly unified that they did not long withstand the thermal shocks and temperature changes of actual service before cracking or breaking. Multipart units were then devised, whose separate shells were assembled by using roughened or scored mating surfaces, joined by Portland cement.

As early as 1900, Locke catalogued multishell pin-type insulators, recommended for AC circuits up to 60,000 volts. By 1907, Locke listed a complete line of pin-type insulators suitable for operating voltages up to 75,000 volts and containing units with as many as four separate shells cemented together. In these early days of electrical development, many painful experiences in the assembly of multipart units developed the know-how to obtain long life and satisfactory service. For some time, it was the practice to furnish only the porcelain shells. The ultimate customer assembled them, often under far from ideal conditions. This experience resulted in the factory-assembled unit, thoroughly tested and proven for its soundness. Resilient coatings were developed to provide a cushion between the shells of the insulator, to withstand without cracking the thermal changes involved in service operation and the mechanical loads imposed by the conductor.



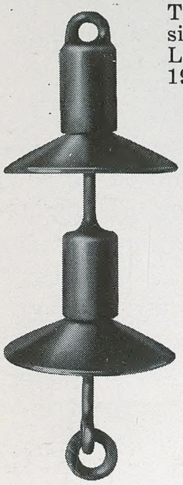
Multipart insulator from Locke catalog of 1900.



This Pin Type Insulator, catalogued by Locke in 1910, had four cemented shells.

DEVELOPMENT

SUSPENSION INSULATORS

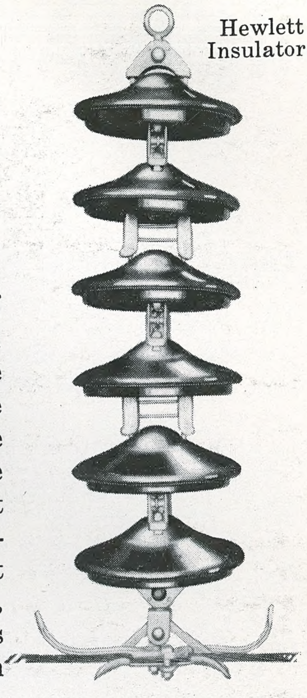


The first Suspension Insulator — Locke patent — 1904.

By 1905 or 1906, transmission voltages of over 100,000 volts required larger insulators than could practically be built into a single pin-type unit with the requisite mechanical and electrical properties. While something remotely resembling the modern suspension insulator had been developed for dead-ending high voltage conductors as early as 1902, it found little practical use. These very earliest suspension units consisted of two conical shells, interspersed with unitary metal parts, cemented to form a strain insulator which supported the load in tension rather than in compression and cantilever as the pin-type units (see illustration).

1906 saw the first cap and pin type and Hewlett suspension insulator, used on the first 110 KV lines built. The cap and pin type units consisted of two cemented porcelain shells, to which a clevis type cap and a split eye bolt pin were cemented. Some of these may still be found on high voltage transmission lines.

Demand for a suspension insulator without cement spurred the invention in 1905 and 1906 of the Hewlett type suspension insulator (above, right), whose load bearing metal parts interlinked each other at right angles, with insulating layers of porcelain between them. The porcelain parts worked in compression. This ingenious design was first used at 110 KV and was popular for many years. Many thousands of these units are still giving excellent service.

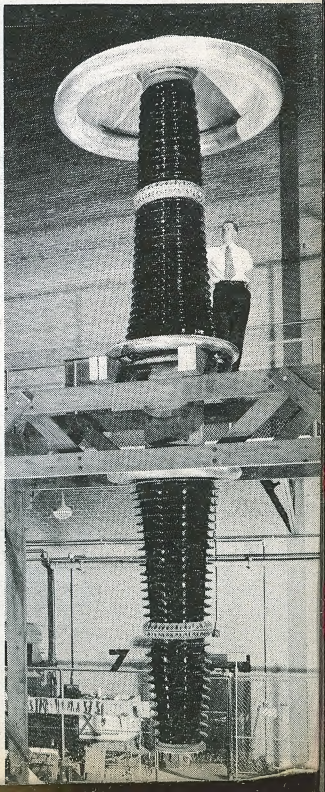


Hewlett Insulators

Simplicity of manufacture and freedom of radio noise required by the advent of radio, brought about the wide use of cap and pin type suspension insulators. In the early units, breakage was caused if the cap was allowed to rest directly on the flange or skirt of the insulator. To eliminate this difficulty, Locke developed the gasket assembly, now universally used. A gasket used in cementing, later removed, leaves a clear space between cap and insulator skirt.

RADIO STRAIN INSULATORS

One of Locke's most significant contributions in the development of extremely high power radio stations has been its ability, through special facilities and know-how, to develop, manufacture and supply large quantities of super-high voltage strain insulators used in supporting the large antenna systems required for high power, low radio frequency radio stations used in world-wide communications. Among these are special tubular insulators with porcelain elements 6″ in outside diameter and over 6 feet long. They develop a tensile strength rating of 30,000 lbs. and have provided an extremely reliable means for supporting large antenna systems. Locke has been a principal source of supply for this type of unit for many years and has also developed an extremely high voltage gas filled antenna lead-in bushing. The illustration below shows this 3-ton bushing in Locke's high voltage laboratory, indicating the magnitude of this undertaking. Internal insulation is provided by inert gas under pressure.



3-Ton Antenna lead-in bushing, 26 feet high overall, probably the only one of its size and type in existence, made by Locke.

INSULATOR DEVELOPMENT (CONT.)

LARGE BUSHING PORCELAIN

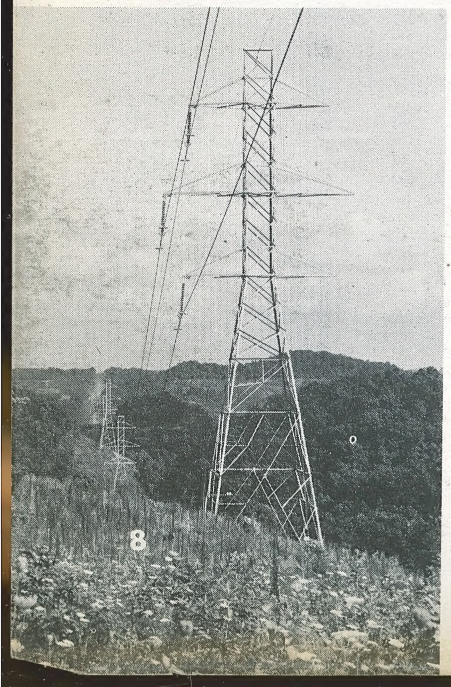
The development of high voltage electric power systems requires extremely large porcelains for oil-filled bushings used on transformers and oil circuit breakers at voltages as high as 400 KV. To fill this need, Locke has developed facilities to produce such extremely large porcelains in large volume. They are used on all Locke high voltage oil-filled apparatus bushings.

GRADING AND CORONA SHIELDS

In the development of extra high voltage lines, there arose the need for alleviating damage to insulator strings and conductors by power flashover. The development of Locke grading shields gave users of high voltage insulator strings protection against such damage and avoided prolonged service outages. With the development of shielded so-called lightning proof lines and fast acting oil circuit breakers, the use of these devices has diminished.

In the recent development of super high voltage transmission lines at voltages of over 230 KV, the earlier experience with grading shields enabled Locke to develop and furnish corona shields for the suppression of corona and radio noise from super high voltage strings. Applied at the line end of suspension and deadend strings, these corona shields have made possible the economical development of insulator assemblies for use at extremely high voltages.

Many thousand corona shield assemblies, providing improved voltage distribution on the insulator strings and corona shielding of conductor clamps and connector fittings at the high voltage end of the assemblies, were furnished on a recent 330 and 345 KV development in this country. With such developments, capable of operation at 500 KV, line to line, Locke continues to be in the forefront of high voltage transmission development.



Modern extra high voltage line, now operating at 330 KV.

TECHNICAL STANDARDS

It has been Locke's policy to promote and contribute to the development of national and industry standards. Through the auspices of EEI, NEMA, ASA, AIEE and the American War Standards Committee, Locke has taken part in the formulation of standards for tests and products in the high voltage insulator industry. Through Locke's high voltage, mechanical and ceramic research laboratories, fundamental data, information and technology have been added to these efforts. Locke made real contributions to the development of AIEE Standards #41, ASC 29.1-1944 Insulator Tests; AIEE Standards #21, High Voltage Bushing Standards; EEI-NEMA Joint Standards TDJ-52 to 57, and is currently cooperating with EEI and NEMA in the preparation of further standards. Locke has also cooperated in the preparation of American War Standards on radio frequency, ceramic insulating materials and radio frequency insulators for use in military equipment.

You may expect Locke to give continued support in the development of standards for high voltage insulators and bushings and promotion of standard material.

ELECTRICAL PORCELAIN AND GLAZE . . . their properties

PORCELAIN

Locke manufactures a variety of ceramic materials, adaptable to specific purposes. Regular insulator lines are made of high quality porcelain. Locke electrical porcelain is a highly vitrified, non-porous insulating material. It offers a rare combination of physical properties . . . great stability and permanence . . . absolute imperviousness to all chemicals but hydrofluoric acid and resistance to thermal shock ranging from subzero temperatures to searing power arcs. It has extremely high compressive strength and rates high in dielectric strength. Locke insulators removed from transmission lines after 50 years of service under severe climatic conditions show no change in appearance, physical or electric properties (see photo, page 6).

PROPERTIES OF LOCKE PORCELAIN

The properties listed below are average values, obtained in accordance with A.S.T.M. Standard Methods of Testing, Serial Designation D-116-44.

Modulus of Rupture unglazed	10,500 lbs./sq. in.
Modulus of Rupture (Locke Compression glazed)	15,000 lbs./sq. in.
Tensile Strength	7,000 lbs./sq. in.
Compressive Strength	55,000 lbs./sq. in.
Density (Bulk Specific Gravity)	2.39-2.41
Dielectric Constant	5.75-6.00
Hardness (Scleroscope)	120
Dielectric strength*	250 volts per mil
Specific Heat (BTU per lb. per degree F)	0.202
Moisture Absorption (Porosity)	Zero
Coefficient of Linear Expansion	3.3×10^{-6} per °F (0°-600°F)
Resistance to Thermal Shock	Good
Power Factor as decimal (48 hrs. soak test in distilled water)	0.0105
Resistance to Impact Ft. lbs. (Charpy)	1.5

*On 0.25" specimens

The dielectric and mechanical strength values, obtained by testing standard specimens, are for general guidance only. The shape of specific designs, the nature of assembled metal parts, mechanical stresses and other factors may appreciably effect the strength of insulators. Design tests should always be made to establish breakdown values.

INGREDIENTS

Only most carefully selected raw materials are used in the manufacture of Locke porcelain. Ball clays and china clays give plastic working properties. Feldspars provide thorough vitrification and non-porosity. Pure pottery flint gives strength and toughness. Constant analysis by skilled ceramic technicians assures proper purity and mixture of these materials.

GLAZE

The exposed portions of Locke insulators are coated with a thin layer of glaze, a mixture of glass-producing ingredients, which provides a particularly smooth surface, offering little hold to dirt and reducing surface leakage. In firing, this glaze becomes an integral part of the porcelain, shown by the interlocking crystals in the photomicrograph (right). By the use of patented

diaphrow

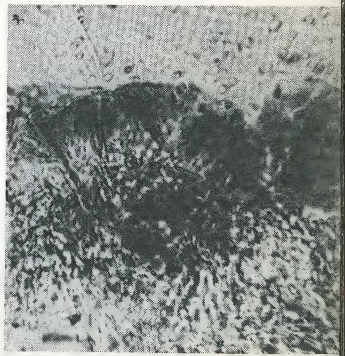


Figure 1
Photomicrograph of cross-section near surface of Microglaze insulator shows how glaze (top) is bonded to porcelain (bottom) by interlocking crystals where they meet (center, dark).

ELECTRICAL PORCELAIN AND GLAZE . . . their properties (CONT.)

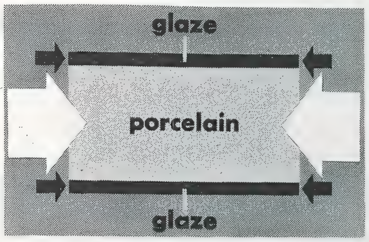


Figure 2
As the porcelain has a higher coefficient of expansion than the glaze, it tends to shrink more than the glaze. But since the two are permanently bonded, the shrinking porcelain subjects the glaze to high compression.

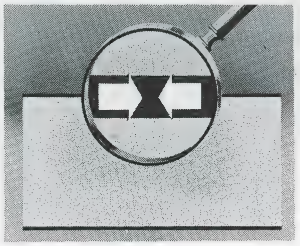


Figure 3
The locked-in compressive stress causes each unit of glaze to be highly compressed, developing its highest strength. The porcelain body cannot be cracked or broken until this force is overcome.

Compression Glaze, porcelain actually gains considerable strength. This is done by selection of glaze with a lower thermal coefficient of expansion than that of porcelain. After firing, as the cooling porcelain shrinks, the glaze tends not to shrink quite as much. (Fig. 2) But as the thin layer of glaze is forced to take the shape of the porcelain body, its particles are highly compressed on the surface of the shrinking porcelain. (Fig. 3) This compressive stress in the glaze must be overcome, before the porcelain will crack under tensile stress.

MICROGLAZE® INSULATORS

It has recently been shown by Locke that the thickness of compression glaze greatly influences its strength-giving qualities. To obtain maximum strength from the glaze-porcelain combination, glaze thickness must be controlled within extremely narrow limits. (Fig. 4) We accomplish this by the use of specially designed glazing machines (see page 22) combined with precise controls over glaze composition. The trademark MICROGLAZE identifies Locke insulators whose uniform peak strength characteristics are produced by glaze thickness control.

LOCKE METAGLAZE STOPS RADIO NOISE

The elimination of radio noise on certain insulators (see pages 16, 23 and 91) calls for a semi-conducting layer on the porcelain surface. This is accomplished by the use of Locke Metaglaze which contains metallic oxides in precise proportion, to obtain specific high-resistance properties. This glaze is applied on the desired areas only, under the regular glaze. The pyro-chemical reactions of firing cause thorough bonding and result in superior radio-influence characteristics unaffected by exposure, chemical fumes, abrasion—even sandblasting of portions of the conducting area. Here too, glaze thickness control is essential, as resistivity varies with glaze thickness. (Fig. 5) Locke's automatic glazing machines safeguard this important element of insulator quality.

FIRING

Brittle unfired porcelain, to which a coat of glaze has been applied, is fired in kilns at temperatures up to 2,300° F. Chemical and crystalline changes taking place at this point, turn the material into tough dielectric porcelain.

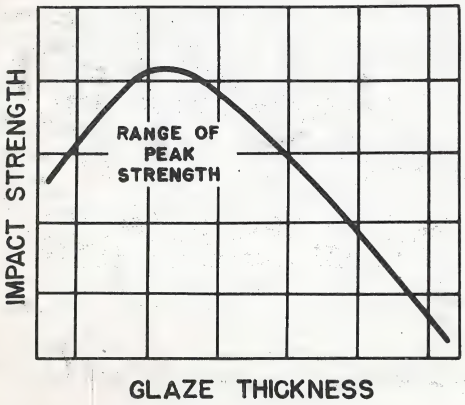
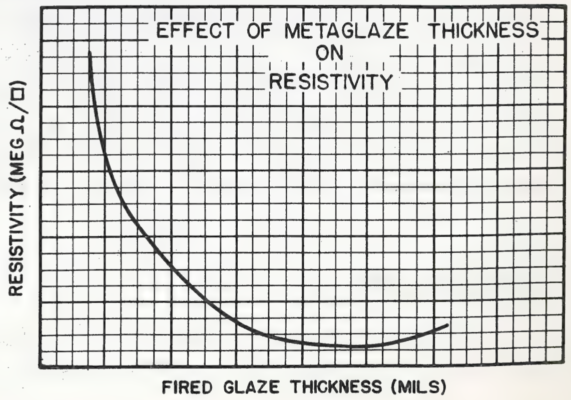
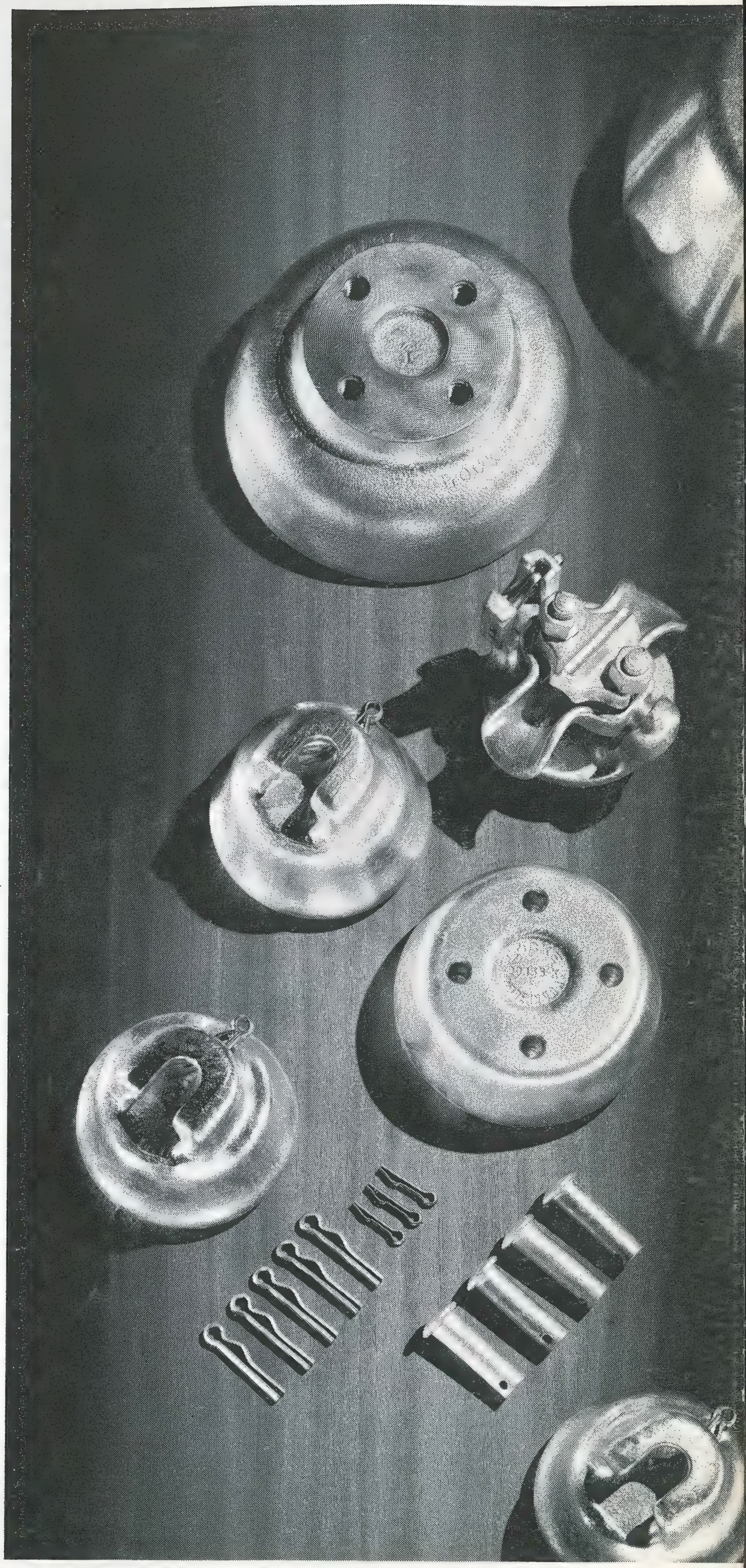


Figure 4 (Left)
Locke research proved relationship between glaze thickness and both flexural and impact strength of porcelain. On Microglaze insulators, glaze thickness is controlled for peak strength.

Figure 5 (Right)
This diagram shows why, on Locke pin type radio noise free insulators, Metaglaze thickness is carefully controlled to achieve minimum resistivity.



METAL PARTS



The metal parts of high voltage porcelain insulators and associated fittings generally consist of malleable iron castings, steel forgings, drawn steel parts and of non-ferrous parts of various types when extreme corrosion resistance or reduction of magnetic losses are important.

Over many years, reliable sources of high quality parts of various types have been developed by Locke. These assure a continuous and reliable supply. Unless otherwise indicated, all ferrous parts have a heavy zinc coating applied by the double hot-dip galvanizing process, described on page 17.

MALLEABLE CAST IRON

This material is ductile and lends itself admirably where strength, ductility, complicated shape, and varying section thickness is required. It is widely used and there are abundant sources of supply of the high quality needed for insulator applications.

FORGED STEEL

Many insulator parts and associated fittings are made of drop forged or upset forged steel, as needed. In general, forged steel is used where sections are small and unit stresses high. The material is tough, but ductile and is capable of developing high unit strength. For extreme corrosion resistance, forged steel parts may be made in low alloy or stainless steel grades, if sufficient quantity is required that mill lots of low alloy or stainless steel forging bars may be economically obtained. Steel forgings are particularly adaptable to the eye and ball bolts of suspension insulators, where a tough, ductile material is desired. They develop high unit strength, provide maximum impact shock resistance and are capable of being bent severely without breaking or cracking.

DRAWN STEEL

The development of deep drawing steel and facilities for producing large quantities of

METAL PARTS & CEMENT

drawn steel parts provides a most economical process for the forming of certain insulator caps formerly made of malleable cast iron. Where production requirements justify the tooling expense involved, drawn steel parts give exceptional strength, impact resistance, improved appearance, and substantial reduction in weight and bulkiness. They eliminate many of the possibilities of defects associated with the casting of malleable iron. Drawn steel parts have the advantage of being extremely smooth, with well rounded edges. This provides an excellent surface for the heavy zinc protective coatings and helps suppress corona in service.

Locke regularly furnishes several of the large production switch and bus insulator units with drawn steel caps.

NON-FERROUS PARTS

Cotter keys used in socket insulators and in cotter bolts on clevis units are of high grade copper alloy especially selected for its temper and resistance to wear, and corrosion. Because of increasing use of ACSR and all-aluminum transmission and distribution conductors, Locke has provided a line of aluminum alloy suspension and strain clamps. The bodies and keepers on these clamps are furnished in a sand cast, corrosion resistant alloy, containing no copper, known as alloy #356 T6. It is extremely corrosion resistant and artificially age hardened. Its use in suspension and strain clamps on conductors carrying 200 amps. or over for long periods, eliminates magnetic losses involved in the use of ferrous parts. For further information on aluminum alloy clamps, see page 53.

CEMENT JOINTS

To join the shells of multipart insulators and to attach metallic to porcelain parts, Portland cement is used. This cement has many excellent properties which recommend it for this use. It is chemically stable, permanent and unaffected by any reagents encountered in high voltage service. It can be readily tested by well developed methods for its suitability to insulator application.

To attain greatest cement strength and reliability, an adequate amount of moisture must always be present during the setting period, assuring complete hydration of the cement. The development of strength may be accelerated by the application of moderate heat. To obtain these results, Locke developed many years ago the practice of steam-curing all cemented assemblies. In this process, after the assembled parts have been fixed in their proper position and alignment (see page 25), the complete assembly is maintained for at least eight hours in an atmosphere of saturated steam vapor, held automatically at a temperature of about 120°F and 100% relative humidity. This assures the presence of super-abundant moisture throughout the setting period and complete hydration of the cement throughout the joints of the insulator. At the same time, the constantly maintained steam temperature during the setting period accelerates the development of strength so that the insulators can be handled, tested, packed and shipped immediately after the curing period. Sufficient strength is developed so that all routine mechanical proof tests can be made in a relatively short time and within a period of seven days, over 95% of the strength has been developed so that performance tests can be made at the end of that time. This Locke development made possible the mass assembly and proof tests of insulators in large quantities on a highly mechanized basis, assisting materially in the supply of large quantities of assembled units and providing good service to customers.

FACTORS INFLUENCING INSULATOR USE

Many factors must be considered in successful application of insulators, some of them depending on the type of line construction. While these variables make it impractical to establish fixed standards for line insulation, certain practices have developed which are applicable in most normal cases.

INSULATION LEVELS

Insulation levels in general usage for pin type and suspension insulators are shown by Figs. 6 & 7. The curves are plotted as bands to encompass the range of levels in normal use. They are based on AIEE standard test ratings and the impulse bands represent the critical impulse flashover voltages resulting from the polarity which yields the lowest values (positive polarity, in most cases). The levels selected within the bands will be influenced by severity of service, importance of the line and economic considerations. For additional details, write for Locke Engineering Data Bulletins Nos. 5 and 6.

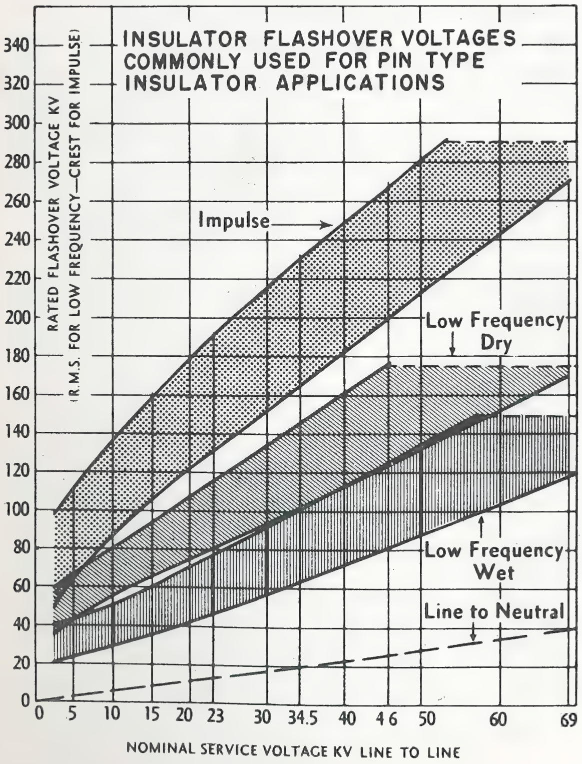


Figure 6

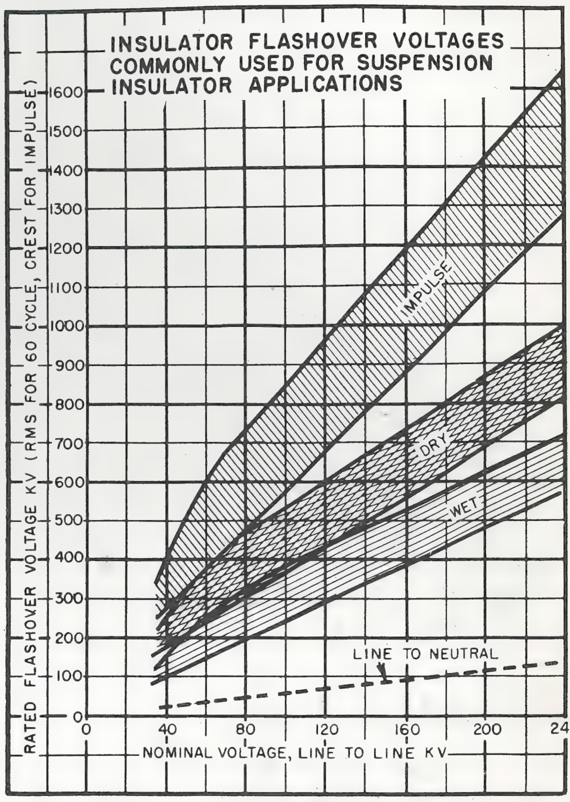


Figure 7

SURGE VOLTAGES

Surge voltages on power lines are generally the result of switching surges or lightning. Switching surges may, under worst conditions, reach crest voltages of 5 to 6 times normal line to ground crest voltages. On grounded neutral systems with modern switchgear, the upper limit will usually be 3 to 3.5 times normal. They are seldom the cause of insulator flashover and almost never of insulator puncture. Impulse voltages due to lightning vary in frequency throughout the country. (See isokeraunic chart of the U. S., page 39). Electrostatic induction, caused by lightning, has been shown to reach probable maximum impulse voltages on power lines of 500 KV. Maximum probable line voltages as result of direct lightning strokes may

FACTORS INFLUENCING

reach 15,000 KV, unless relieved in some manner.

Experience of many utilities indicates that with isokeraunic levels of 30 to 65, one may expect from 0.8 to 1.5 direct strokes per mile of line per year, although not all strokes will be capable of producing the maximum voltages mentioned above. Lightning wave shapes may vary widely from the AIEE standard 1½ x 40 MS test wave. It is apparent from figures 6 and 7 that maximum lightning surge voltages are far above normal impulse flashover levels of normal line insulation.

While a properly designed insulator will normally flashover under steep wave front lightning impulses, insulator punctures can and do occur. This is explained by the schematic time curve in Figure 8. Curve A is the voltage-time curve for the air gap around the insulator, (for flashover). Curve B is the volt-time curve for the solid porcelain insulation (through the insulator). The volt-time curves for nearly all solid insulators are relatively flat with a sharp upward break at short times, like curve B. Hence, it is inevitable that the two curves shall cross somewhere, even though there may be a large safety factor between them at the critical impulse flashover time. To reduce the probability of puncture under very steep wave fronts, more safety factor between flashover and puncture voltage at the critical breakdown time can be provided. However, the possibility of puncture cannot be entirely eliminated.

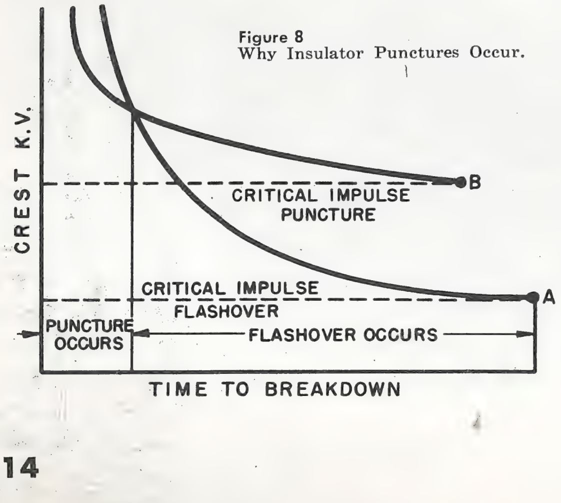


Figure 8
Why Insulator Punctures Occur.

For further detail on the above subjects, write for Bulletin: Factors influencing the application of distribution line insulators.

SURFACE CONTAMINATION

The electrical performance of high voltage insulators is influenced by three major factors —the dielectric strength of the insulating element, the dielectric strength of the surrounding air and contamination on the surface of the insulator. While the first is seldom a cause of concern today and the second subject to some variations, the last factor is the most serious and difficult to predict or control.

Surface contamination by deposits of atmospheric dirt on the insulator varies widely. Modern insulators are designed for natural cleaning by wind and rain and will operate successfully under normal deposits of atmospheric dirt.

In some areas near the sea or near heavy industry, chemical and cement plants, the rate of dirt accumulation and severity of contamination is so great that they affect insulator performance. This is particularly bad when

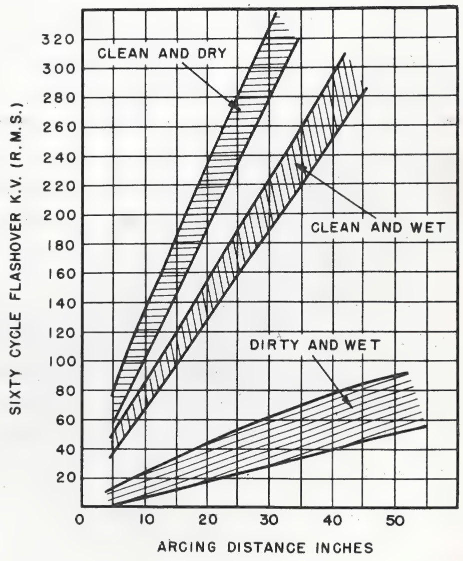


Figure 9—Effects of contamination
The band marked "Dirty and Wet" shows laboratory tests of practical insulators. They were tested with heavy surface contamination and represent extreme dirt conditions in service.

INSULATOR USE (CONT.)

Pin type insulator with chemical and dust deposits, accumulated in one year's service.

dirt deposits, built up during long dry spells, are moistened but not washed by subsequent periods of fog or light misty rains. Some common contaminants like Portland cement, chemical by-products and locomotive smoke, tend to stick to insulator surfaces so that wind and rain will not remove them.

So long as the dirty insulator surface is dry, the insulators will usually work successfully. Most contaminants do, however, contain soluble elements which produce electrolytes with water, resulting in extremely low surface resistivity. The effect is more severe if thick layers of inert matter act as a sponge to hold the conducting solution on the surface.

Such contamination results in a number of objectionable conditions. Leakage currents can cause burning or charring of wood crossarms and poles. The change in the voltage gradient over the insulator and reduction in its flashover voltage by the conducting film may, if severe, cause flashover at normal line to ground voltage. Local temperature rise caused by sparking, combined with local voltage gradients may result in insulator puncture.

In operation in very dirty areas, corrosion of metallic parts near insulators may be accelerated. This can be due to electrolysis caused by uni-directional properties of the leakage current, the burning of protective films by arcs terminating on the metal surface, the generation of nitric acid from the ozone produced by the corona and by heating which increases normal corrosion rates.

The curves in Figure 9 give some idea of how drastically the flashover voltage of insulators may be reduced when surfaces are extremely dirty. Generally, the following guidance can be given for application of insulators in contaminated areas:

1. Oversize insulators should be used. It is not uncommon to use 34.5 KV or 46 KV insulators on 13 KV circuits in very dirty areas.
2. In special areas, limited clearance or other conditions may make fog type insulators desirable.
3. To prevent crossarm and pole burning, wood members should be bonded and grounded. Conducting insulator pins should be used with pin type insulators.
4. It may be necessary to wash insulators periodically.
5. In some areas, the use of oil or wax surface treatments will improve operation and make washing easier. Locke Insulcone* (see page 202) is recommended. It is made from silicone oils to give chemical stability and prevent charring.

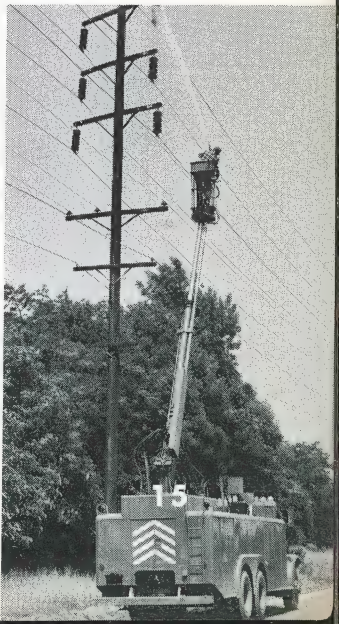
For further reference, see AIEE paper 48-255: Insulator Surface Contamination. Copies may be obtained by writing to Locke.

CLEANING INSULATOR SURFACES

Locke insulators are designed for successful operation under conditions of normal atmospheric contamination with no attention whatsoever. Ordinary wind and rain provide sufficient washing action to prevent the accumulation of dangerous surface deposits.

In areas where atmospheric contamination is critical, or where extremely long dry periods are followed by intervals of light, misty rains and fogs, it may be necessary to clean or wash insulator surfaces. Such areas may be very close to the sea coast where substantial salt deposits result from wind blown spray or in heavy industrial areas with great varieties of industrial waste and chemical dusts. Occasional washing may even be required in rural areas where long dry seasons are followed by fogs or light rains which are not sufficient to wash away the accumulations of heavy fertilizer layers.

Because many kinds of dirt may occur on insulator surfaces, it is very difficult to establish any generalized technique which will always be satisfactory. In many



Hot line washing from top of mobile unit.

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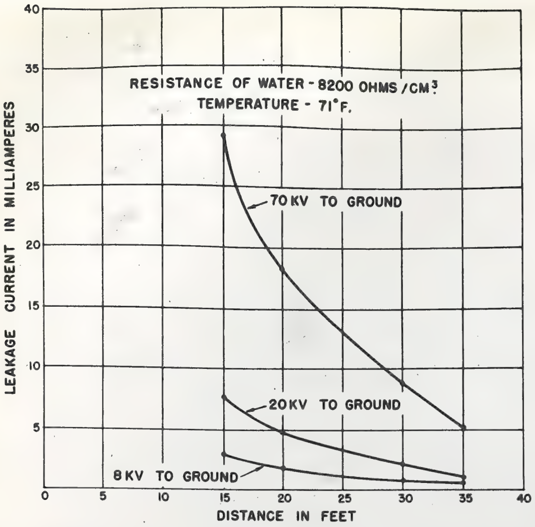
*T. M., General Electric Co.

FACTORS INFLUENCING



Leakage current through a stream of water from energized screen to experimental nozzle orifice of ¾″ and nozzle pressure of 100 lbs./sq. in.

cases, successful washing is achieved by merely flushing insulator surfaces with clean water. Best results are obtained if water jets are applied at high velocity. This is often done by delivering small quantities of water at pressures of 1000 pounds per square inch through ⅛″ diameter nozzles. This washing equipment must be designed for the purpose —ordinary fire hose with ⅝″ diameter nozzles can be very successfully used.

Much of this washing is presently done while the conductors are energized. In such cases, rigid safety routines must be established and the work should be under the supervision of competent and experienced personnel. Using high pressure water jets, insulators can normally be washed, while energized, with a clearance of from 15 to 16 feet between the nozzles and the line conductor, even with circuit voltages as high as 230 KV. The hose nozzle should be solidly grounded and the individual handling the nozzle should stand on a solidly grounded plate.

Water resistivity for hot washing operations should preferably be above 3000 ohms per inch cube, although cases of successful washings have been reported with lower water resistivities. For very dirty insulators, the lower end of the string or stack should be washed first, progressing upward. This prevents dirty water from cascading over dirty insulators which may cause a flashover. A second pass should then be made over the units, to rinse away the dripping dirty water.

Where contaminants tend to bond tightly to insulator surfaces, a suitable oil or wax coating of the insulator surfaces will prevent a bonding of the dirt. The silicone materials are particularly good for this purpose because of their high stability and resistance to char. While no material has been 100% successful in all kinds of contamination atmospheres, Locke Insulcone (page 202) has often been used for this purpose with considerable success. Locke Insulcone may be applied to insulators by spraying while the line is hot. It has, in many cases, made cleaning easier, and sometimes made artificial cleaning unnecessary.

Where dirt deposits are so firmly adherent that they cannot be washed off, and where the use of oils and waxes will not prevent their adhesion, it is usually best to remove the insulators from service for cleaning. In some cases, soap powders work quite well, in others the application of hydrochloric acid is required. Where acid is used, it is imperative that metal parts and cement joints be protected from the acid. The insulators must be thoroughly flushed with large quantities of clean water before being restored to service, or the soap, alkali, or acid residues left on the surface may produce leakage effects as bad as those resulting from the original dirt deposits.

RADIO NOISE

All electrical circuits produce some high frequency disturbance. The problem of eliminating radio noise depends on radio signal strength in the area traversed by the line, and the line's nearness to dwellings, airports and other areas where radio communication is employed. Generally, if the signal strength is 32DB or more above the noise level, good reception can be obtained.

Radio noise from insulators is caused by high voltage gradients across portions of the insulator, resulting in ionization of air. Where air or other insulation is overstressed so that corona or sparking occurs, radio noise may result. The left half of figure 10 shows a cross-sectional view of a typical pin type insulator. At the conductor or tie-wire, small air gaps exist in series with the porcelain and the metal pin upon which the insulator

INSULATOR USE (CONT.)

is mounted. If the voltage on this insulator is sufficiently increased, the small air gaps at the conductor or tie wires will break down electrically and corona or streamers will result. This may first appear as a glow and then as streamers, originating at the point of stress and will spread over the surface of the insulator. Resulting transient disturbances will appear as noises in a radio receiver.

Locke pin type and switch and bus insulators as well as bushings whose application involves the possibility of radio noise, are treated with Locke Metaglaze which free these insulators of radio noise by providing a conducting layer on the surface of the insulator and short-circuiting the air gap. This is shown at right side of figure 10. (For details on Locke Metaglaze, see page 10 and for application to specific insulator types, see appropriate catalog section.)

Accurate radio influence voltage tests are frequently made at the Locke High Voltage Laboratories, conforming with the recommendations of NEMA publication 107, "Method of Measuring Radio Noise." For further information on this subject, write to Locke for Engineering Data Bulletin No. 10 "Radio Noise Tests."

While laboratory tests are important in determining radio noise characteristics of insulators under standardized conditions, the magnitude of radio frequency noise voltage produced by insulators in service is dependent upon such factors as the design of the insulator, the construction of the line and the impedance which the line presents at radio frequencies.

CORROSION PROTECTION-GALVANIZATION

The ceramic elements of Locke high voltage insulators are impervious to atmospheric contaminants normally encountered in service. As insulators with metallic parts must be resistant to metal corrosion to assure their full service life, corrosion protection is an important factor in insulator manufacture.

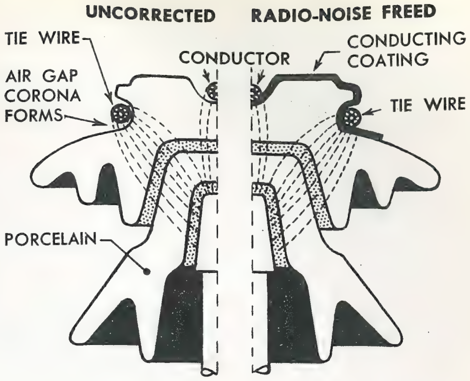


Figure 10
Corona formation, with resulting radio interference, is eliminated by applying special conducting glaze (right) to porcelain.

Continuing research has proven that double hot dip galvanizing is the best form of overall corrosion protection. A galvanized coating is much more than a protective film on the surface of the metal. A properly applied hot-dip galvanized coating is actually blended into the surface of the base metal, so that there is no sharp line of demarcation between the base metal but a series of layers consisting of highly corrosion resisting alloys of zinc and iron. On the surface of these alloys lies a layer of pure zinc, 3.5 mils thick. The firm bond between zinc and iron eliminates possible chipping or scaling.

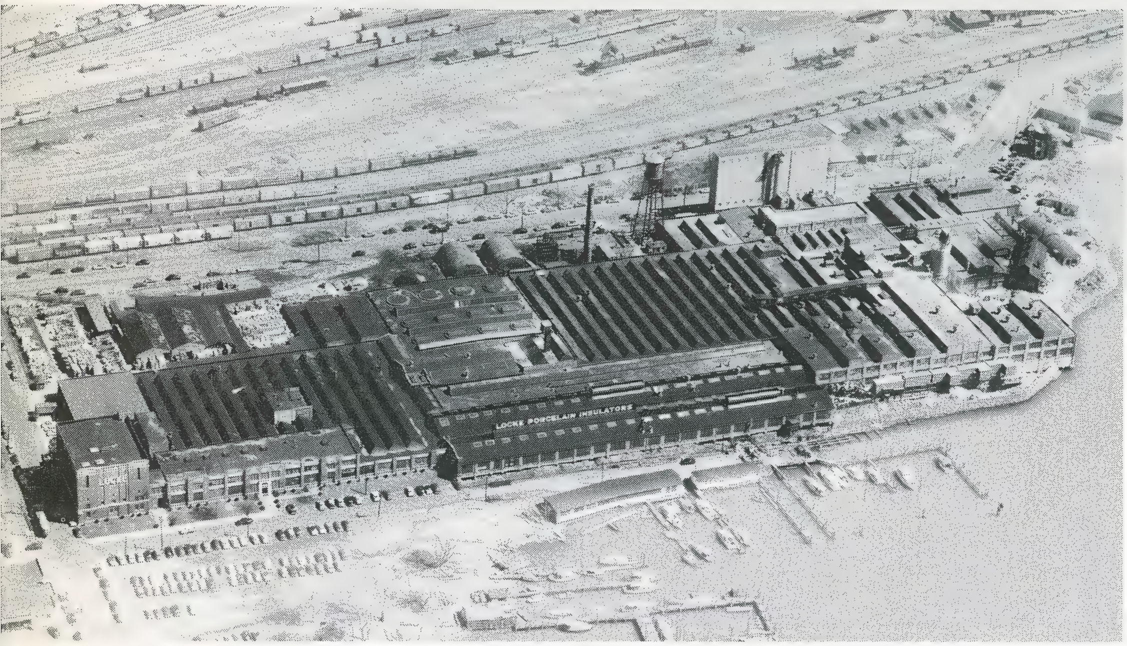
Because zinc is anodic with respect to iron, small scratches or other defects in the zinc surface will not tend to spread. The zinc around bare spots up to ⅛″ diameter will absorb the effects of electrolytic currents while the base metal is protected. The resulting rate of deterioration of the zinc around small defects is insignificant. This additional resistance to corrosion is a great advantage of galvanizing.

To assure a sound, uniform, properly galvanized layer on hardware parts, controls in the Locke galvanizing plant assure thorough cleaning of the metal surface before galvanizing, the use of proper grade of zinc, proper galvanizing temperatures and correct period of immersion (see photo, page 25).

The uniformity of zinc coating is measured frequently by use of the Preece test (ASTM-A-239-41)—a series of immersions in a copper sulphate solution of specified concentration and temperature. Elimination of zinc at any point becomes apparent if bright copper deposits form. Locke galvanized parts meet all the requirements of the Preece test.

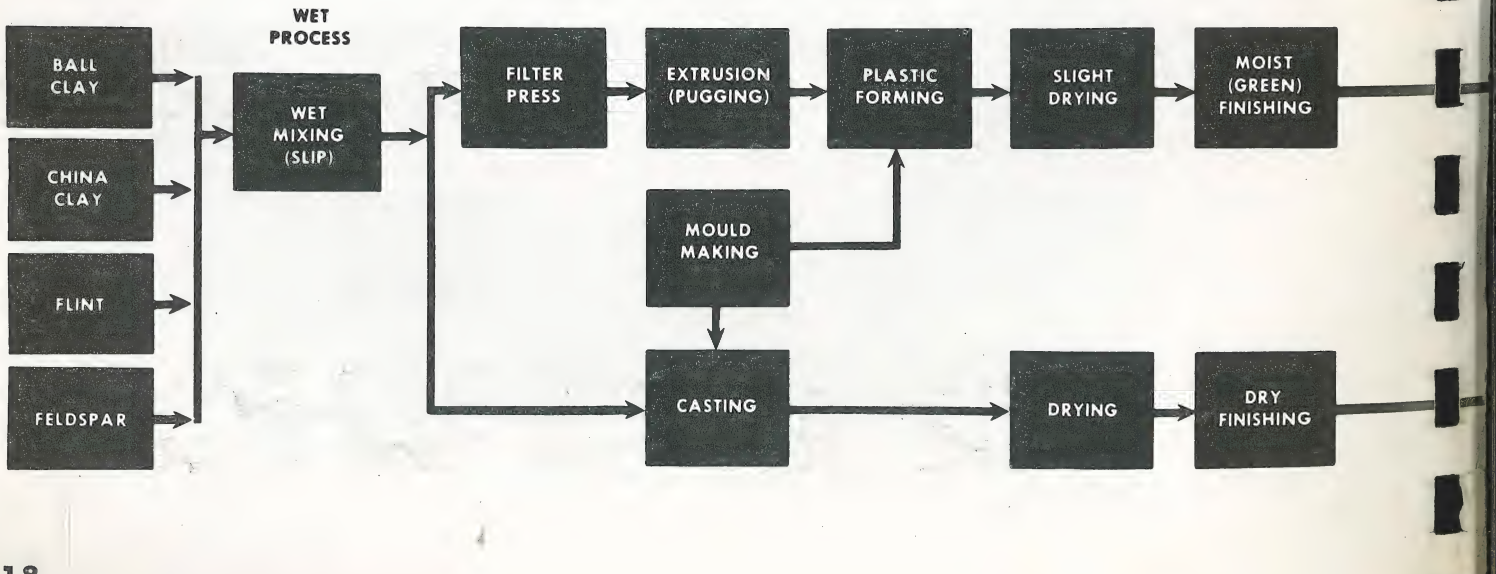
Corrosion protection other than galvanizing is available upon special request.

MANUFACTURING LOCKE INSULATORS . . .



The Locke plant in Baltimore, Maryland, is the country's largest such facility, in a deep water port. Its location is also ideal for rail, truck and air transport. Covering 500,000 sq. ft., it offers extensive storage facilities for raw materials and finished products. Over 1,000 people are normally employed in manufacturing insulators for transmission and distribution systems all over the world.

The user of porcelain insulators is mainly concerned with the operating characteristics of the finished product and its performance in service. Because porcelain insulator manufacture is subject to practical limitations, you will want to be familiar with the basic manufacturing steps for wet-process porcelain insulators, shown below.


BALL CLAY
CHINA CLAY
FLINT
FELDSPAR
WET PROCESS
WET MIXING (SLIP)
FILTER PRESS
EXTRUSION (PUGGING)
PLASTIC FORMING
SLIGHT DRYING
MOIST (GREEN) FINISHING
MOULD MAKING
CASTING
DRYING
DRY FINISHING

. . . QUALITY BY PREDETERMINATION

Quality by predetermination has become a by-word at Locke. Sound engineering principles and measurements form the basis of the Quality Engineering approach to manufacturing control in the plant. The members of the Quality Control section are, in effect, your representatives in our plant.

The Locke quality approach begins with engineers who periodically inspect the sources of each raw or basic material to insure a continuous uniform supply of only the highest grades of materials. Advance samples from each car load of material are sent to Locke for pre-testing, prior to arrival of the material at the plant. Samples are taken after the material arrives and further exhaustive tests are conducted. Incoming lots of metal components are sampled, based on statistical techniques and destructive tests are made to determine full compliance with specifications.

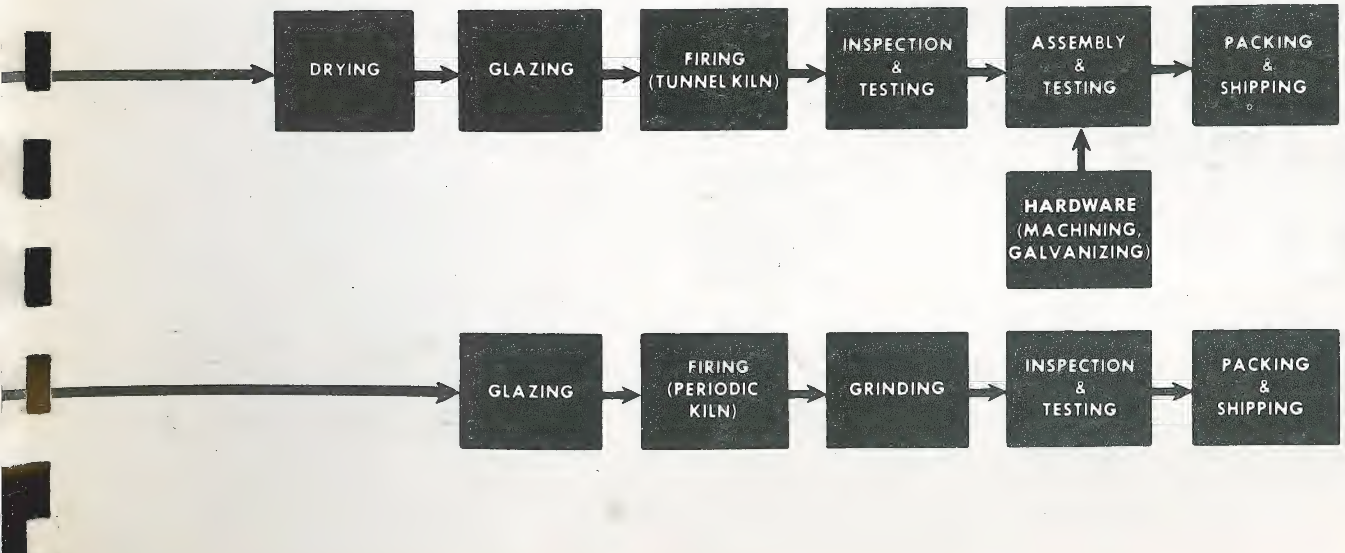
At every stage of manufacturing, precise controls insure high quality and uniformity of the finished product.

Quality Control techniques do not end with the packing of insulators. Continuous destructive and ultimate value tests give a complete, precise and up-to-date picture of the quality levels. This is obviously the "proof of the pudding." Completely satisfactory test results are a prerequisite for the shipment of units and their continued production.

On the following pages, some of the many Quality Control measures at Locke are illustrated.

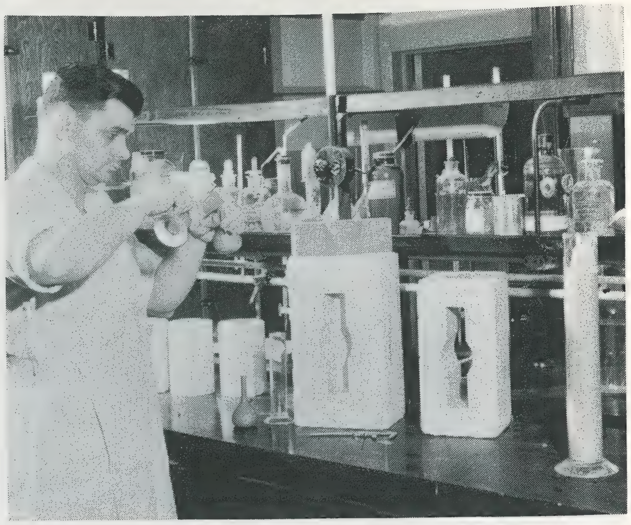
The raw materials are mixed in proper ratio and dispersed in water to make a thick fluid, called slip. This slip is processed either by extrusion, shown in the top row of the chart, or by casting, as shown along the bottom row. Both methods include the progressive removal of moisture as manufacturing progresses, culminating in the firing process which produces strong, ageless electrical porcelain. Casting is mainly used for very large shapes.

To see many of these operations and the quality controls practiced for your protection, turn to the following pages.



RAW MATERIALS HANDLING

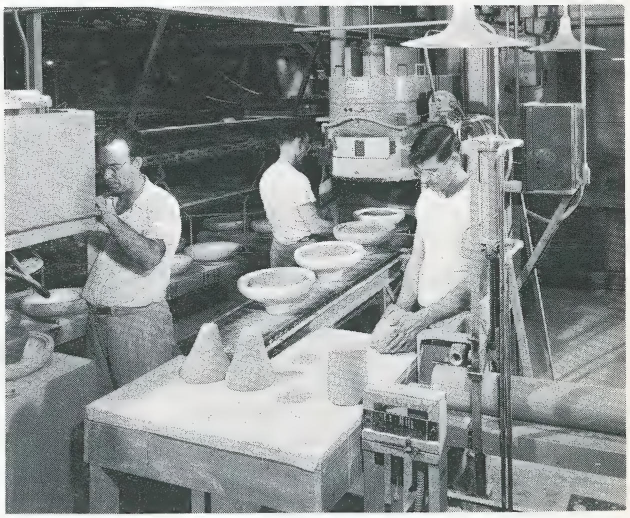
Raw materials—clays, feldspar and flint—are chosen for their inherent physical and chemical properties for the production of fine electrical porcelain. 225,000 lbs. arrive daily from the mines, to be automatically loaded into these huge silos.



All raw materials must meet specified standards of purity. Laboratory tests of all incoming shipments determine fusability, color, screen residue, modulus of rupture, shrinkage, particle size distribution and moisture absorption after firing. Here, a technician measures specific gravity and casting properties of clay.

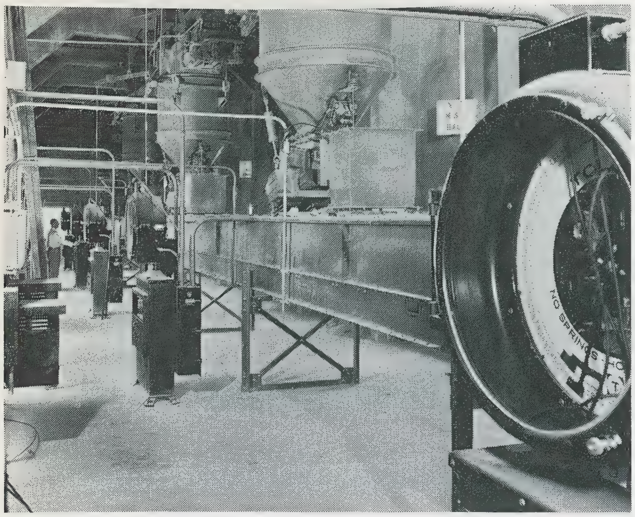
FORMING THE

The mixture of raw materials and water, checked for temperature, specific gravity and plasticity, filtered of magnetic impurities, is de-watered in plate-and-frame filters, regulated on a constant pressure time basis. The plastic body is now ready for forming.

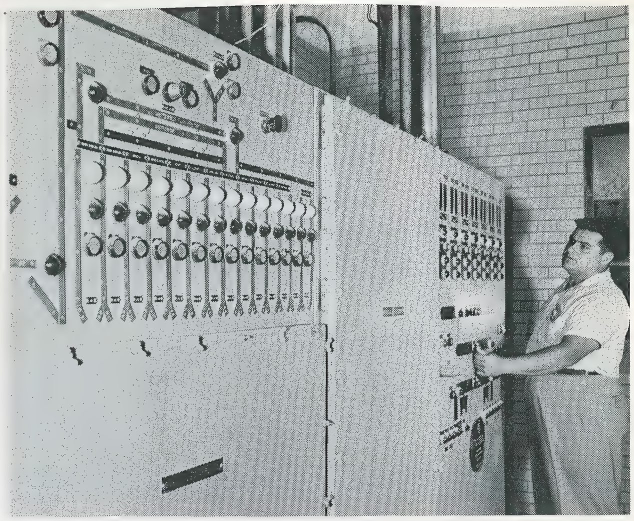


Plastic clay is forced through one of many vacuum-type extrusion mills which form cylindrical sections of constant plasticity and moisture content (lower right). These sections are shaped, partially forced into porous moulds (left) which move on to the hot pressing operation.

AND CONTROL

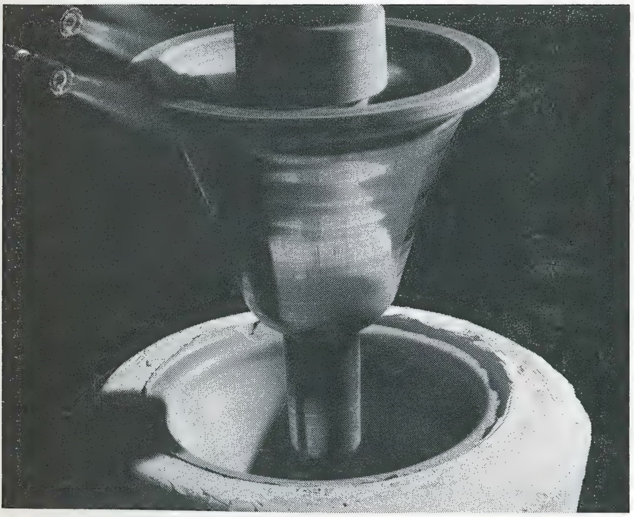


This machinery performs the important weighing and combination of raw materials. The material is stored overhead in huge silos and fed into automatic hoppers. Predetermined quantities are weighed by automatic scales and deposited on conveyor belts to be carried to mixing machines.



An electrical control system monitors all storing and batching operations, eliminating the possibility of errors. From the very beginning, automatic equipment, combined with skilled ceramic control, assure the quality and uniformity of the finished porcelain insulator.

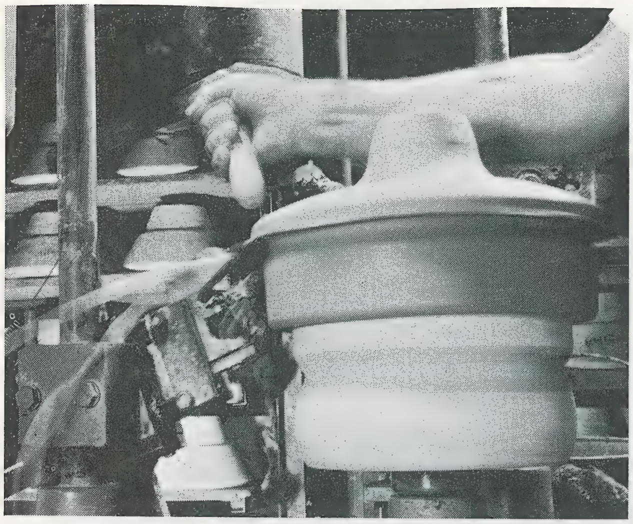
INSULATOR



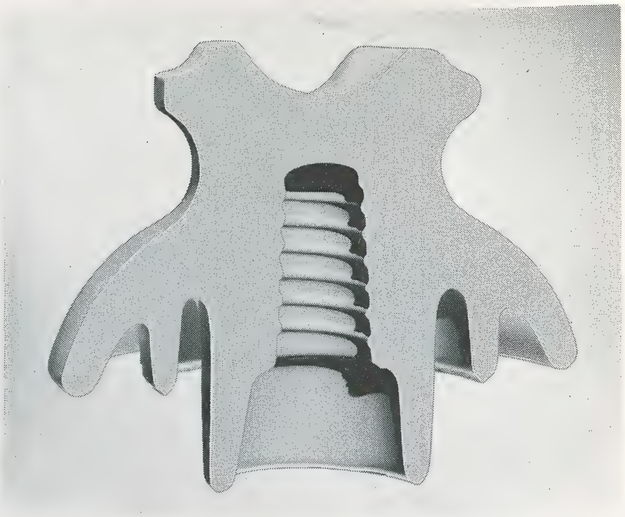
Here, the insulator shell is formed by a hot, rotating, steel die. The die in this illustration has the shape of the inner contour of a switch insulator shell. The mould shapes the outer contour of the shell.

After travelling along a conveyor-dryer under a battery of fans for a specified period of time, the clay has hardened—and shrunk—sufficiently to remove the formed insulator shell from the mould. This system dries clay at a predetermined rate to insure stress-free material.

FINISHING, GLAZING AND

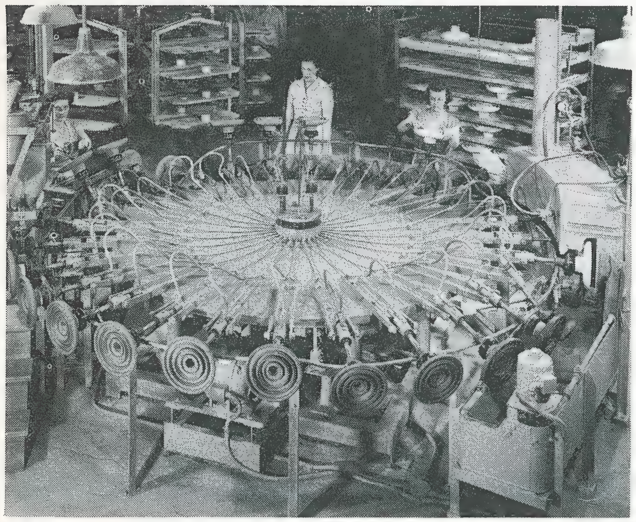


In the finishing operation, the rotating clay shells are trimmed to bring them to the precise shape required. As the clay will shrink about one-twelfth of its size between forming and firing, the fog-type suspension insulator shell, being trimmed here, is somewhat larger than final size.

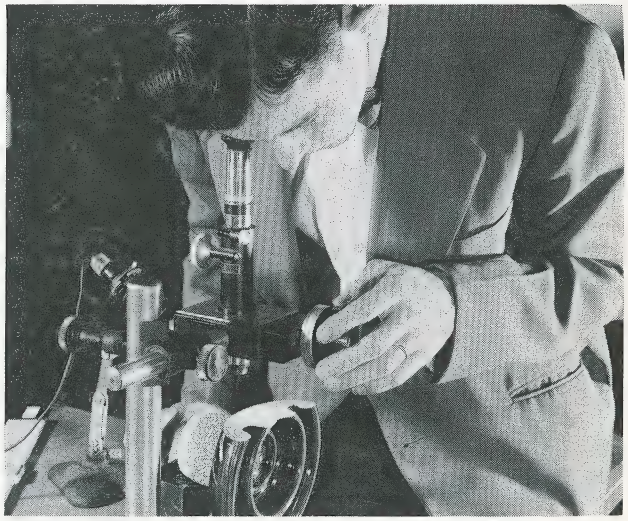


Cut in half to check the perfect formation of pin hole threads . . . this is the basic form of a low voltage pin type insulator. These threads are formed by a plunging die which reverses direction when it has formed the pin hole, thus leaving the threads properly shaped.

GLAZE THICKNESS CONTROL—



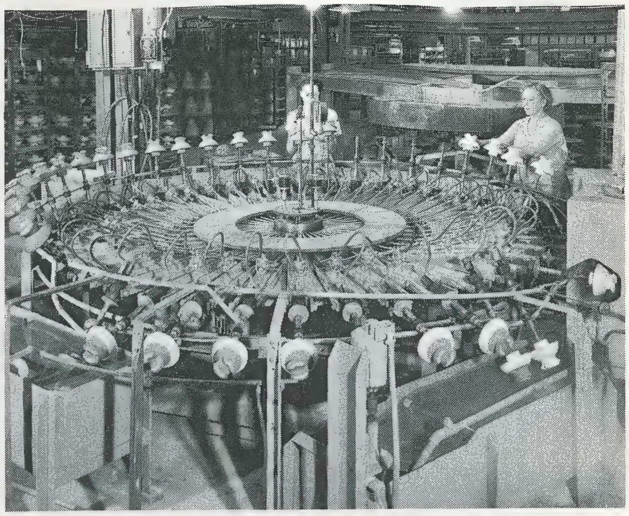
The impact resistance of Locke Microglaze suspension insulators is created here. This automatic glazing machine controls the variables of glaze application to assure uniformity of glaze coverage and thickness. Sand bands, for the later attachment of hardware, are applied automatically



Daily checks with the Brinnell measuring microscope determine the glaze thickness on Locke Microglaze insulators. Here, a suspension insulator shell from which a slice has been cut, is checked for thickness of the microscopic layer of glaze bonded to its surface (See page 10).

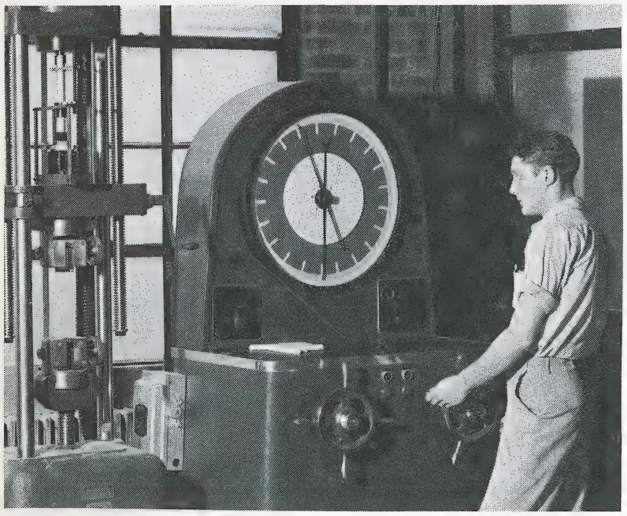
RADIO NOISE—PROOFING

The final shaping of low voltage pin type insulators is accomplished by this machine which carries the still plastic blank past rotating knives which cut it into the desired shape. Each knife makes a progressively larger cut. Before removal, the catalog number is stamped on its side.

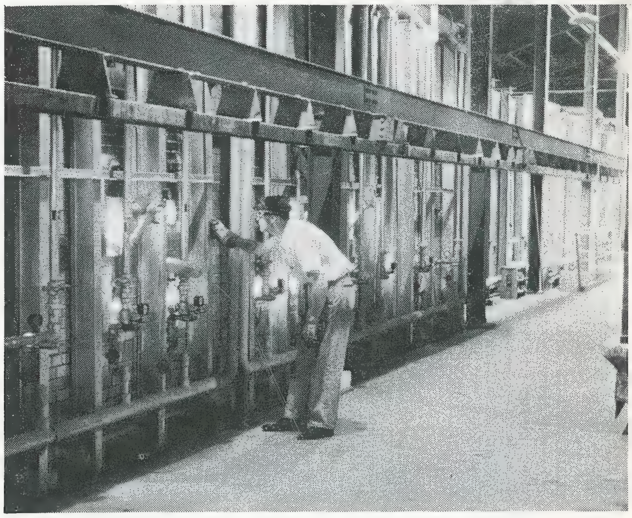


On this pin type insulator glazing machine each insulator is glazed twice. First, a uniform band of semi-conducting Locke Metaglaze is applied around conductor and tie wire grooves. Then, covering glaze is applied over the entire insulator. This produces freedom from radio noise (See pages 10 and 91).

DRYING—FIRING

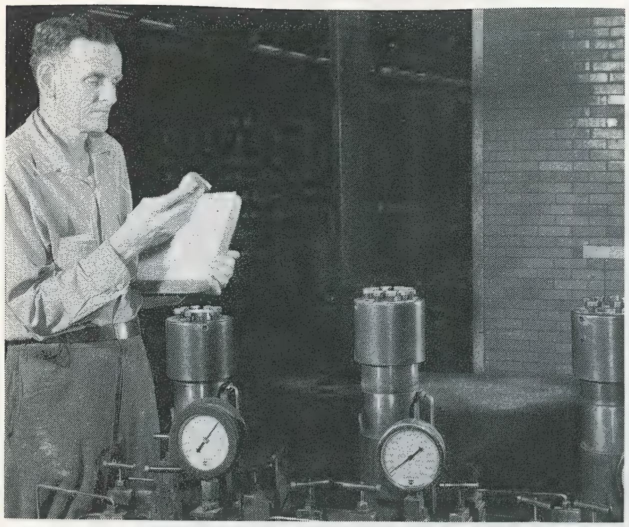


Tests in the Locke ceramic laboratory prove that glaze thickness must be controlled within a narrow range to achieve maximum impact resistance of porcelain. The strength-giving qualities of glaze derive from its high compression and thorough bonding to the porcelain surface (See page 10).

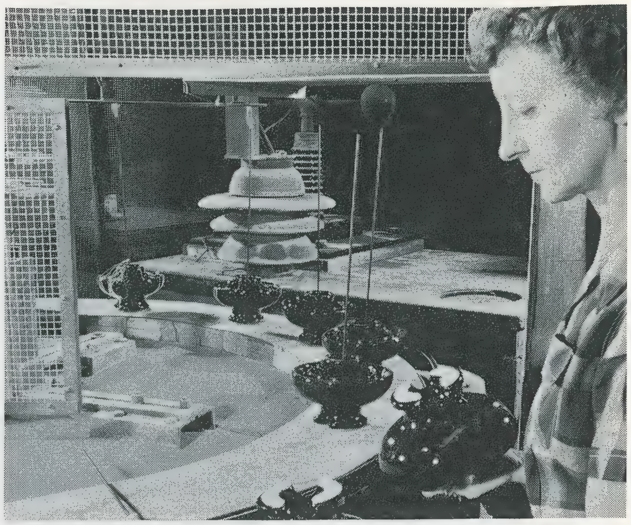


Complete vitrification is achieved in electronically controlled gas fired tunnel kilns. As brittle shells travel through the kiln, they meet increasing temperatures until the white heat in this mid section converts them into hard and ageless electrical porcelain.

TESTS OF UNASSEMBLED

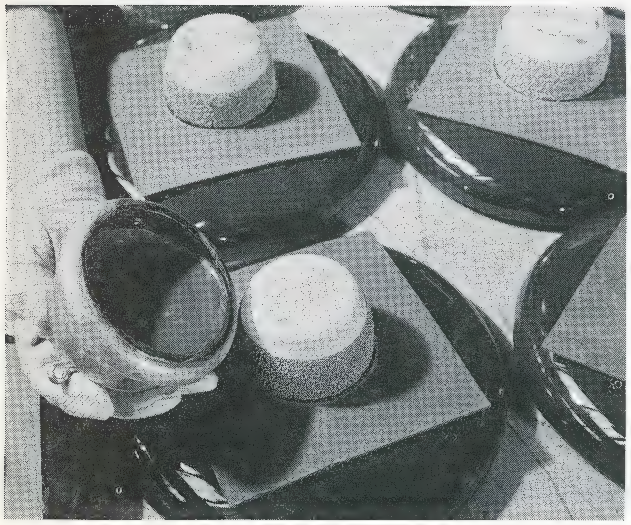


Dye tests, based on carefully determined sampling techniques, assure thorough vitrification, avoid porosity. Immersed in dye under enormous pressure in these steel cylinders, the porcelain is then broken to check if dye has penetrated into its surface.

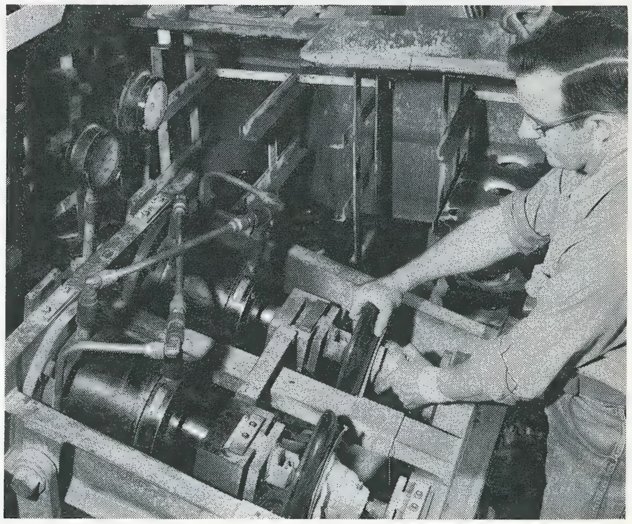


Finished low voltage one piece pin type insulators undergo rigorous 60 cycle electrical testing and careful visual inspection before packing and shipment. Note the electrical discharges flowing around the insulators on the wheel in the background.

SUSPENSION AND SWITCH



Hardware is attached to suspension units by Portland cement—chosen, mixed and cured under rigorous control for maximum strength. Hardware surfaces touching cement are coated for cushioning and to resist chemical action. Paper washer separates lip of cap from porcelain in assembly, is later removed.

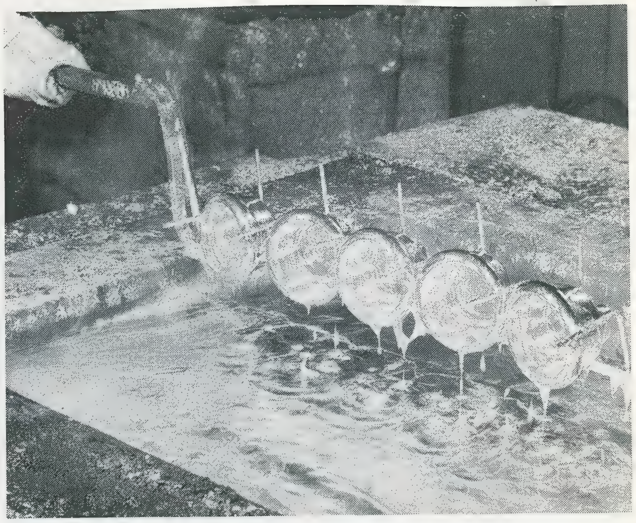


After the cement is thoroughly cured, this machine tests all 10″ and 12″ suspension insulators to 50% of rated strength. This exceeds standard test requirements and coincides with recommended maximum working load which is one-half of the insulator's rated strength. This test precedes the final electrical test, so that insulators damaged in the pull test can be eliminated.

PORCELAIN • METAL PARTS

QUALITY CONTROL

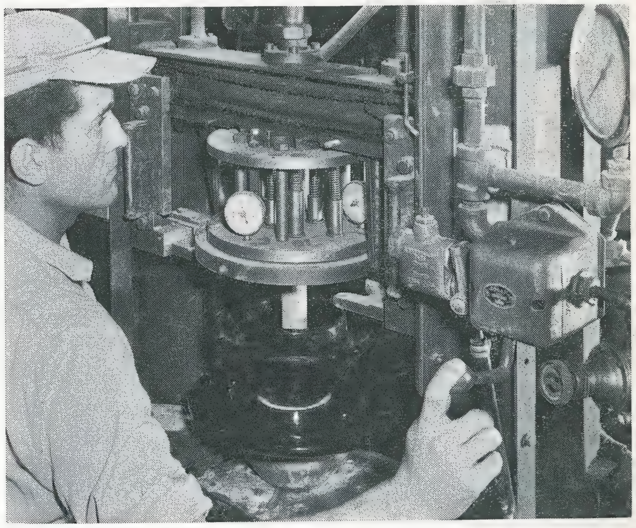
Here, suspension insulator caps are tested to destruction with subsequent analysis of metallurgical properties. This, combined with checks of dimensional fidelity with precision gauges, is applied to suspension insulator hardware, based on recognized sampling techniques.



Locke's double hot-dip galvanizing technique, characteristic of all Locke hardware components, assures results far in excess of Preece test requirements (See page 17). These caps will be carefully inspected before being assembled with previously tested cotter keys.

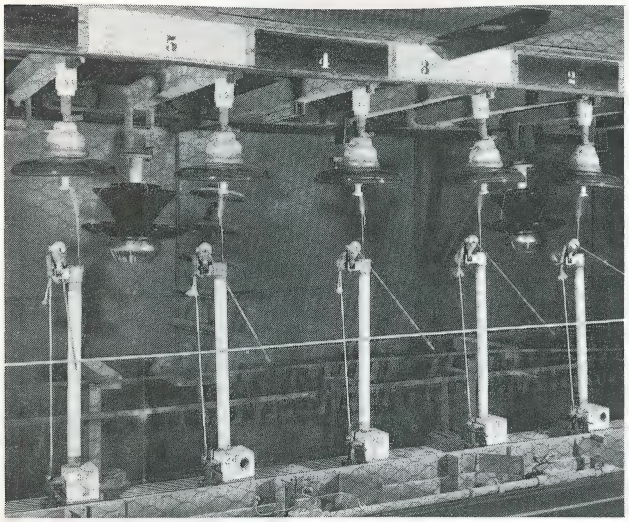
INSULATOR ASSEMBLY

In these conveyorized jigs, electrically tested porcelain shells for switch insulators are accurately assembled with caps and pins, using carefully measured amounts of freshly mixed cement. From here, they move through a steam chamber where the cement cures while the insulators are held in alignment (See page 12).

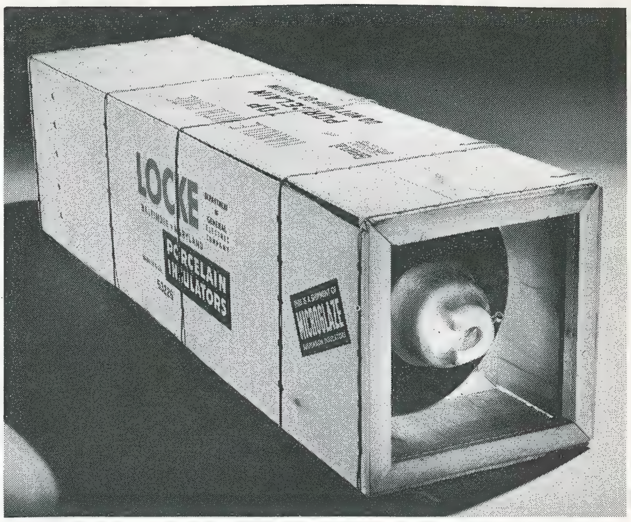


After curing, the now completed switch and bus insulators are tested for parallelism, bolt hole alignment and height. A pull test according to proposed NEMA Std. TDJ-58 is applied. This gives full assurance of cement soundness and accurate assembly.

FINAL INSPECTION

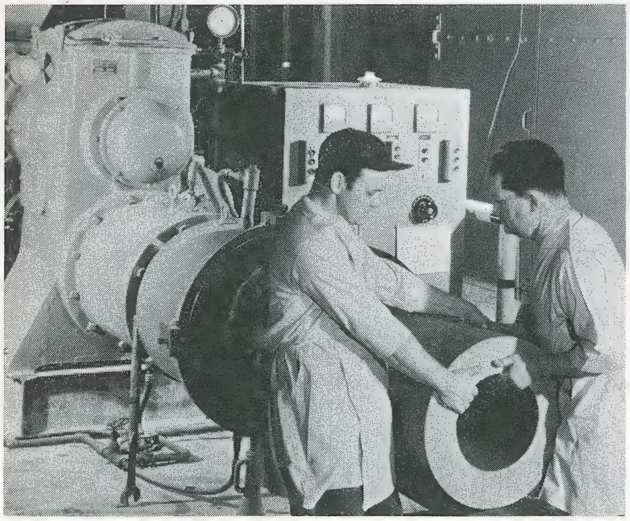


Each suspension and switch insulator travels along this conveyor as it undergoes a 60 cycle flashover test of at least three minutes. A color marking system assures elimination of electrically unsound units. Careful visual inspection follows.

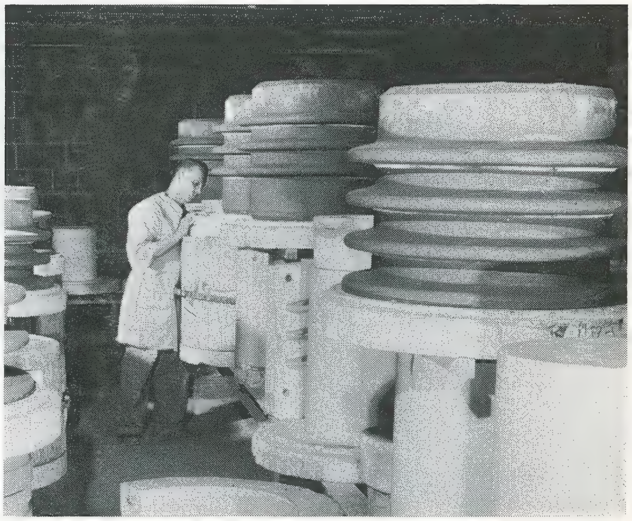


Control procedures and design tests—mechanical, electrical, puncture, thermal, impact, porosity, Preece and destructive tests of hardware—all of these bear witness to unexcelled quality control at Locke . . . your guarantee of uniform and dependable performance.

MANUFACTURE OF LOCKE

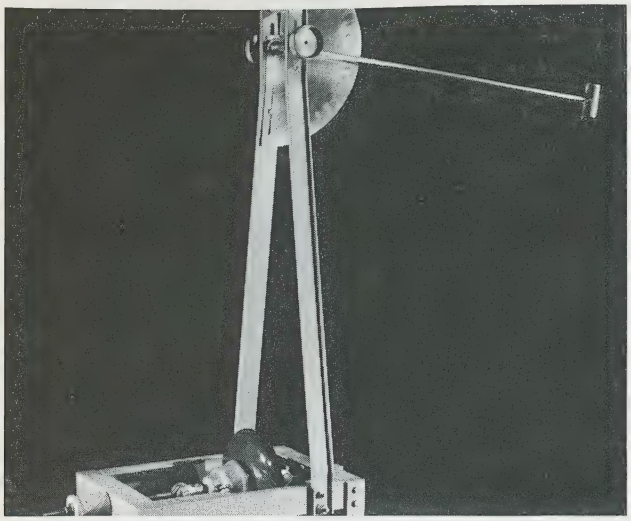


In the manufacture of large porcelain shells for Locke apparatus bushings, this giant extrusion mill is used. Individual pieces or "pugs" of clay, weighing as much as 600 lbs., are then dried under careful control of temperature and humidity.

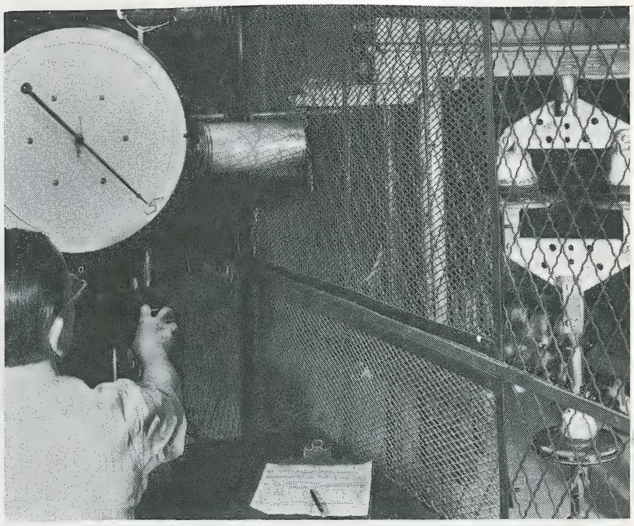


Large bushing porcelain sections are also formed by casting. Plaster moulds are filled with a dispersion of clay in water. The plaster draws the water from the clay, causing it to set and allowing the mould to be removed.

AND DESIGN TESTS

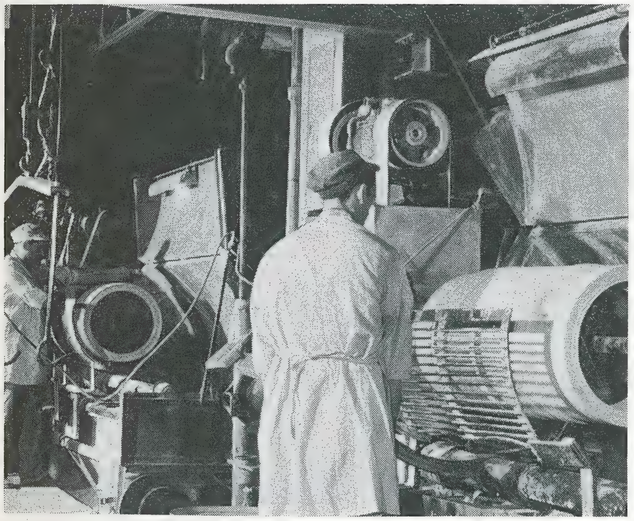


The impact test, pioneered by Locke, subjects random lots of suspension insulators to hammer blows of increasing severity (See page 34). The last blow withstood before failure is the impact strength. Locke Microglaze suspension insulators normally score high on this important test.



Random samples of suspension insulators such as the one at the lower right, above, are subjected to destructive pull tests under electrical load (M&E). Nature of failure, ultimate values and other pertinent data serve as basis for analysis and provide a continuous record of performance (See page 34).

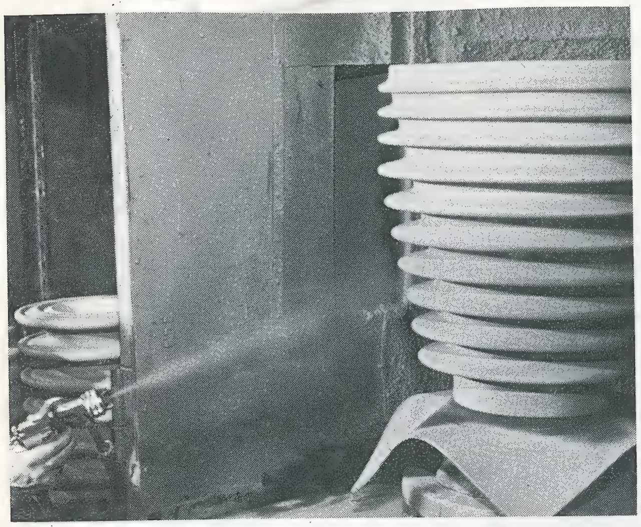
APPARATUS BUSHINGS



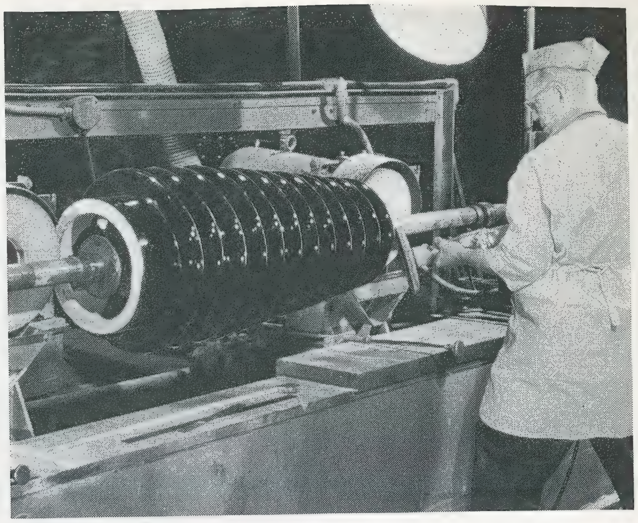
A profile lathe which operates somewhat like the small lathe on which duplicates of keys are made, holds a dried clay blank. The cutting tool follows a steel profile of the desired form and cuts the external corrugations into the revolving clay. Suction machinery removes dust.

To detect possible flaws in the tender clay, it is coated with a dispersion of fluorescent particles in an oil of very low surface tension and then examined under ultraviolet light. Any tiny crack would draw the oil and fill with fluorescent substance, making the defect brilliantly apparent.

MAKING AND TESTING

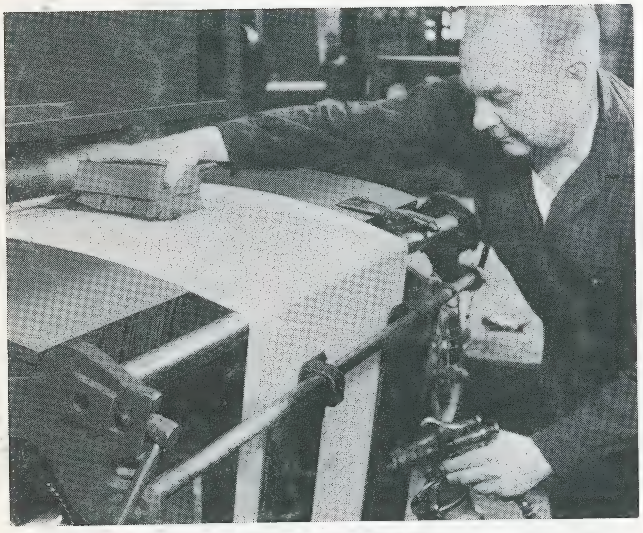


Glaze is applied here. Glaze is a slurry of glass-producing elements in water. The composition has been selected to have a thermal coefficient of expansion less than that of porcelain. Firing will reduce it to a uniform glassy film of Compression Glaze which adds greatly to porcelain strength in service.

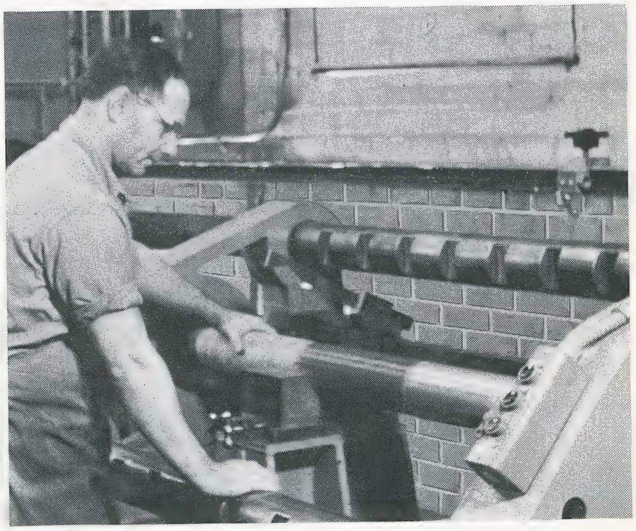


The fired bushing porcelain is ground to provide for accurate sealing with the nitrile synthetic rubber gaskets in the actual bushing. Two grinding wheels rock forth and back across the ends of the revolving bushing while the operator removes burrs.

ASSEMBLING AND TESTING THE



As paper flows upward to wind around the center conductor of the type LC apparatus bushing, resin is melted to form impervious laminated Herkolite* insulation. A layer of conducting Rescon* paint, sprayed into the core, adds to the bushing's excellent radio noise characteristics.



The snug press fit of the ground sleeve over the bushing core is accomplished in this press. A heated aluminum ground sleeve is forced over the precisely machined Herkolite core. As the sleeve contracts in cooling, a snug interference fit results, which eliminates possible oil leakage.

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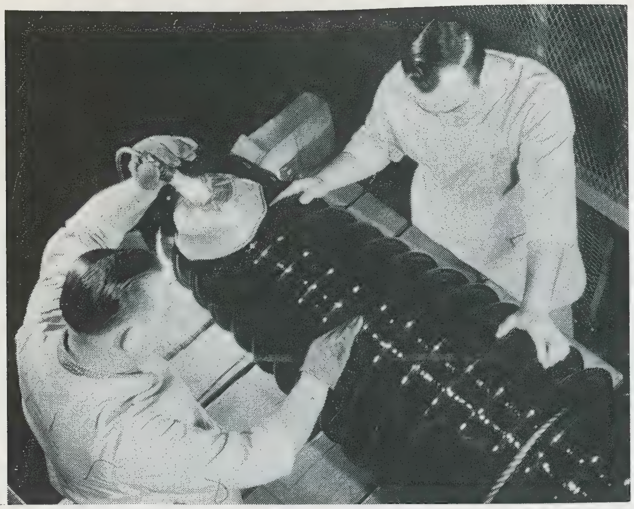
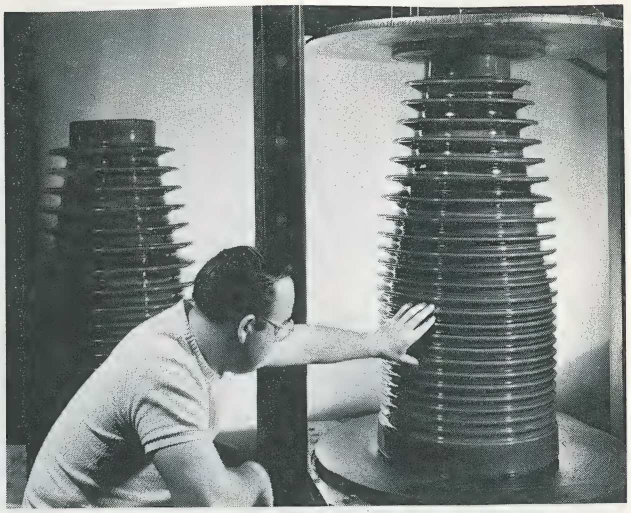
*T. M., General Electric Co.

THE BUSHING PORCELAIN



In addition to careful visual inspection, the porcelain must withstand a specified transverse loading test to be sure that its strength is adequate. In this rack, a steel cable placed around the bushing is pulled downward with a force ranging from 8,000 to 20,000 lbs.



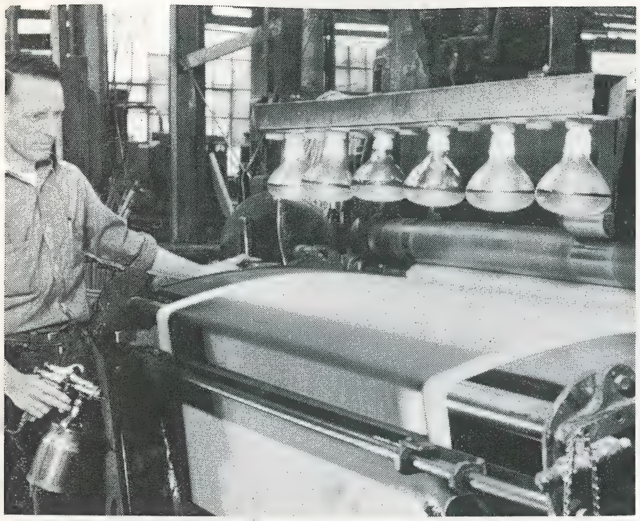
The last test of the porcelain is an oil pressure test. The porcelain is compressed between two smooth steel plates, filled with oil under high pressure and checked for possible leaks through joints or tiny cracks on the end surfaces. Only now is it ready to be installed on the bushing.

TYPE LC BUSHING

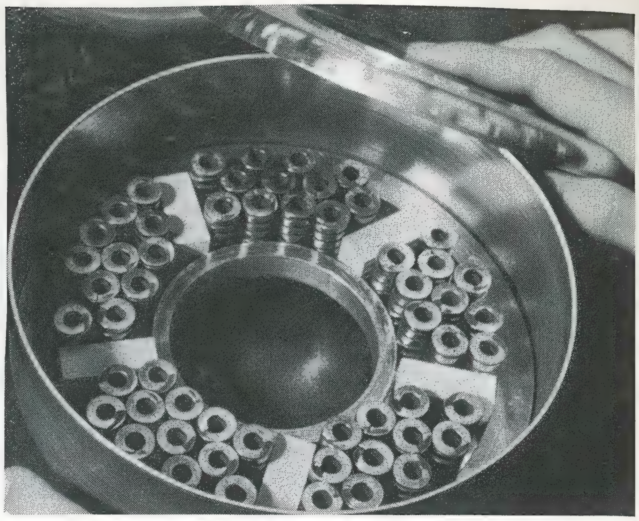
The Belleville spring washer in the bushing top assembly is a dish-shaped piece of special bronze. It assures tight center clamping of the bushing in service, regardless of temperature. By checking the flatness of the washer with a gauge, this man makes certain that the gaskets are in proper compression.

To test bushing tightness, a small amount of Freon gas is injected under pressure. The "pistol" held by the operator would detect the slightest leakage of gas through the bushing. This modern method assures trouble-free operation better than ever before.

ASSEMBLING THE

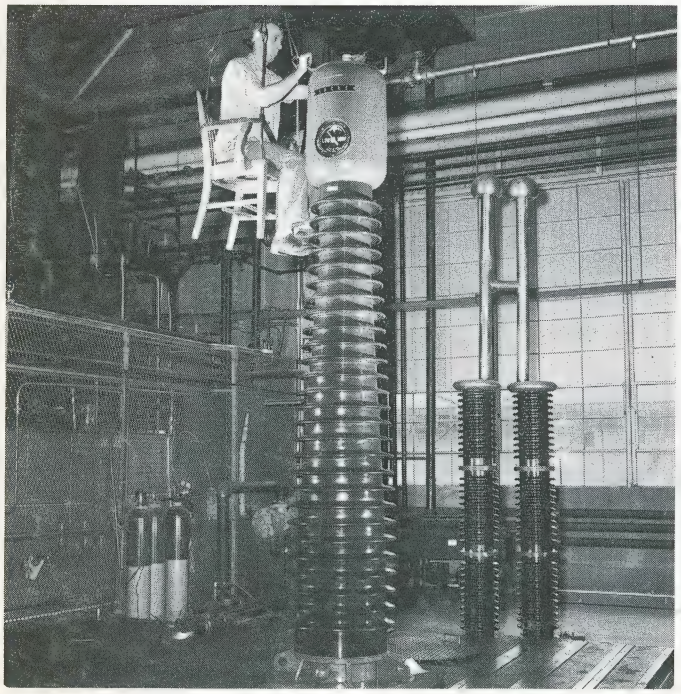


In winding the internal core of the type U high voltage apparatus bushing, carefully inspected Kraft paper is wound around the conductor to be later thoroughly impregnated with oil. Conducting voltage stress equalizers are imbedded to give the bushing its superb freedom from corona.



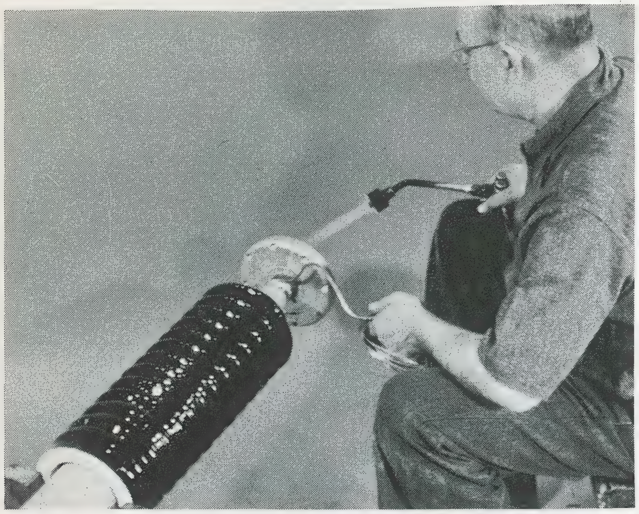
Many steel springs are incorporated into the top assembly of the U bushing to maintain proper compression. Superior to a single spring, they avoid a continuous magnetic path around the conductor and give a wide safety margin in case of spring failure.

RIGID TESTS ASSURE



In the test area, completed bushings are put through careful and extensive performance tests such as 60 cycle withstand and flashover, radio noise and power factor tests. The designs also meet impulse withstand and flashover, corona intensity and elevated voltage life tests. Here, a test lead is being attached to the terminal of a 287.5 KV bushing, resting in an oil filled test tank.

TYPE U BUSHING

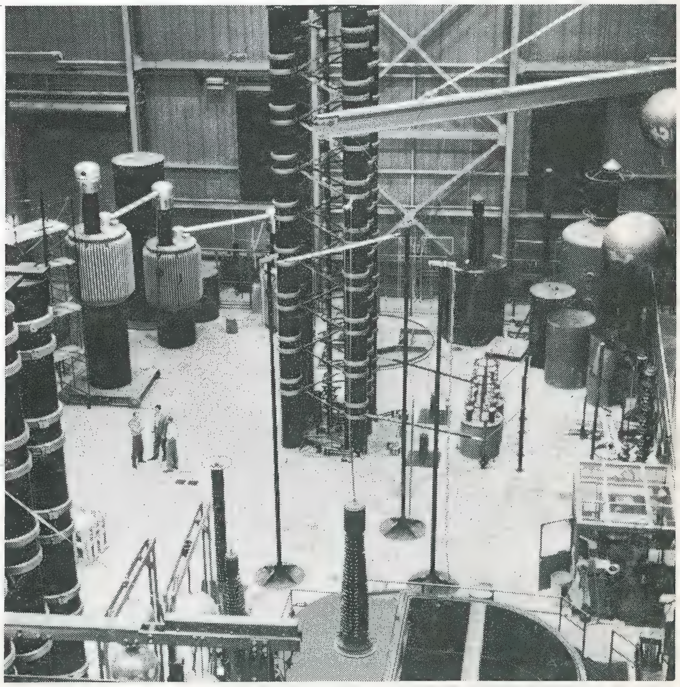


The bottom washer is attached and sweated to the lower end of the U bushing core. It has tapped holes and an annular line contact bottom surface to provide for attachment and alignment of circuit breaker contacts. The oil drain plug is also in this washer.

After the parts of the bushing are assembled, a powerful hydraulic ram bears down on the cover with a force of up to 30,000 lbs. depending on bushing size. This maintains required gasket compression, alignment stability and highest porcelain strength to withstand operating shocks.

BUSHING QUALITY

The largest bushing designs are tested in this High Voltage laboratory, believed to be the world's best equipped of its kind. Here, giant bushings can be put through 60 cycle dry withstand tests at 1,030 KV. With such test equipment, Locke is now ready to engineer, manufacture and test bushings for 440 KV circuits or test level of 2,000 KV BIL. When future requirements will call for even higher voltages, Locke will stand prepared to serve equipment manufacturers.



SUSPENSION

DESIGN FEATURES

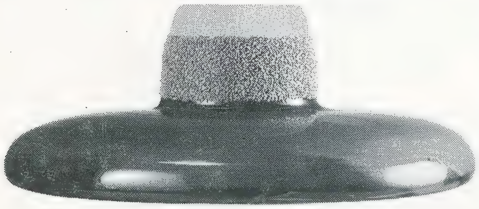
Millions of Locke suspension insulators are in service on transmission lines throughout the world under all conceivable operating conditions. Since the first suspension insulator produced by Locke in 1904, they have been continually improved to give you better and stronger insulators. Only recently, the accomplishment of glaze thickness control, with resulting peak strength uniformity, produced the Locke Microglaze Suspension Insulator. (For details, see page 10).

PORCELAIN

Proper thickness and soundness of porcelain are determining factors in resisting puncture and mechanical breakage. In the design of Locke suspension insulators, balance is achieved between required puncture strength and needed mechanical strength. The most important part of the porcelain shell is the head section which is enveloped by the cap. This section bears the mechanical loads transmitted from pin to cap through the cement. Here, also, electrical gradients and puncture hazards are greatest.

SAND BELTS

Sanded areas on the head section and in the pin hole provide a locking medium for the transmission of mechanical loads from the porcelain surface to the cement (see photo). The special sand consists of ceramic granules, bonded to the porcelain surface by glaze.



BALL and EYE BOLTS

The double hot-dip galvanized metal pin is designed with an offset area for the transmittal of load from the pin to the cement within the pin hole. This area of the pin is coated with a permanently flexible compound to prevent chemical action between cement and zinc coatings and to absorb expansion differences between cement and metal. The resiliency of the sand granules and the coating on the load-bearing hardware surfaces serve to distribute the load evenly between stressed members.

CAP

Enveloping the porcelain head, the cap is made of forged steel or malleable iron, double hot-dip galvanized. Its lip section is formed at a precise angle to its side to control the direction of load transmission between cement and cap. The inner surfaces are coated to prevent chemical action and to provide a cushion.

When the cap is cemented to the porcelain, a clearance is left between its lip and the porcelain surface. This eliminates hazards due to differential expansion of cap and porcelain.

OUTER SKIRT

The skirt section provides sufficient separation between cap and pin to withstand normal line to ground voltage, switching and lightning surges without flashover. Protected corrugations and hoods increase the surface leakage distance by increasing the leakage path over which leakage currents must flow. This reduces the probability of arc streamer formation, developing into flashovers.

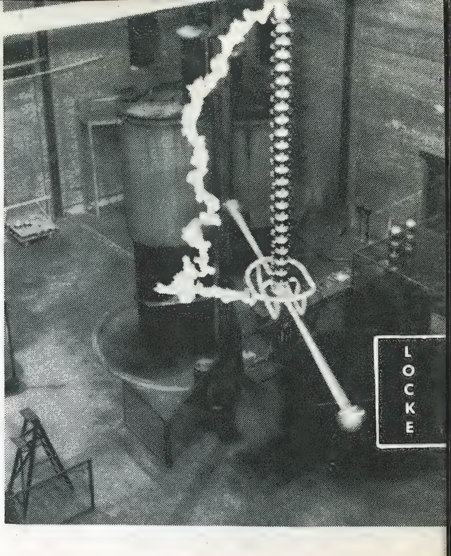
STRING ASSEMBLY

Connections between suspension units are made by means of caps and pins. The ball of the pin is inserted into the T-shaped recess of the cap until the upper area of the ball is seated in the matching contour of the cap. The spread cotter key in the cap is then driven forward. This gives a positive lock and prevents accidental separation of the units. Suspension insulators in each package are fully joined and ready for installation.

STRING LENGTH AT STRAIN POINTS

Points of strain such as dead-end or large angle structures are usually important to the structural stability of the line. These are

INSULATORS



Extensive flashover tests in the Locke High Voltage Laboratory help determine number of insulators in high voltage suspension assemblies.

often located where safety is specially important—at road and railroad crossings, or where other utilities are crossed. At these points, you can least afford mechanical or electrical failure. Since electrical troubles are often followed by mechanical troubles, longer strings are recommended in the strain position than at regular suspension points.

Flashover values, both 60 cycle dry and impulse, for insulator strings in the strain position are less than those for the same string length in the vertical position. The sagging of horizontal strings reduces their arcing distance. (See Fig. 11)

Distortion of electrostatic field at the line end of strain strings where changes in direction are involved, results in 8 to 10% reduction in the 60 cycle dry and impulse flashover values of strings in the horizontal position.

Under wet conditions, drip water does not accumulate on a horizontal string as it does on a vertical string. This produces higher 60 cycle wet flashover values than those of a vertical string. Also, the 60 cycle wet flashover value of a horizontal string is only slightly lower than its 60 cycle dry flashover value. (See Fig. 12)

For more complete details, write for Locke Engineering Data Bulletin No. 8.

FOG TYPE INSULATORS (See page 46).

DESIGN CHARACTERISTICS

LONG, PROTECTED LEAKAGE DISTANCE—Half of entire 17″ effective leakage distance is on protected under side of insulator where entrapped warmth tends to dissipate fog and moisture. Deep corrugations on under side act as barriers, damping ionization and minimizing streamer formation. This reduces both audible and radio noise.

INCREASED IMPACT STRENGTH RATING of 55 inch-lb. results from improved design. High impact and mechanical strength is maintained by careful control of glaze uniformity and thickness which is typical of Microglaze insulators.

WIDE SPACING between units makes string assembly and cleaning in service much easier. REDUCED NET WEIGHT lessens installation cost.

WIDER SPACING between skirts and between shells of adjacent units breaks up rain drip, reducing tendency to bridge over. This results in fewer flashovers, less radio noise and more reliable line operation.

RADIO INFLUENCE VOLTAGE is well below standard NEMA ratings under standard test conditions.

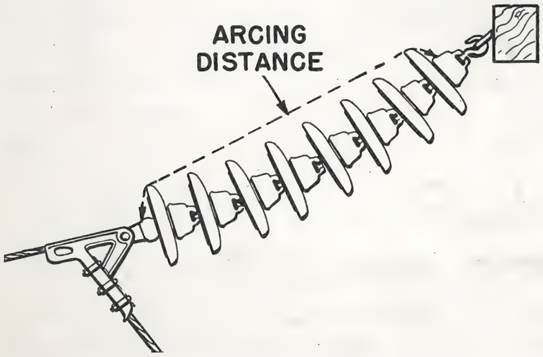


Figure 11
Sag of horizontal string reduces arcing distance.

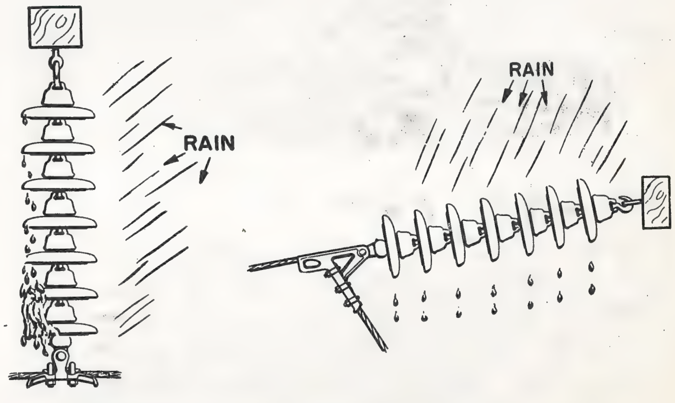


Figure 12
On strain string (right), no rain accumulation or bridging occurs.

TESTS

MECHANICAL AND ELECTRICAL (M & E) TESTS

The combined mechanical and electrical strength rating of a suspension insulator is assigned by the manufacturer to indicate the combined mechanical and electrical strength of the unit. It is the loading in pounds at which any part of the insulator fails to perform its function either electrically or mechanically, when voltage and mechanical stresses are applied simultaneously. (Ref. TDJ-52, p.48, & ASA C-29.1-1944, p.204).

The specified testing procedure requires that:

(a) The tensile load shall be applied between the terminal fittings in line with the axis of the specimen.
(b) The load shall be increased rapidly to 75 percent of rated insulator strength and beyond this point increased from 15 to 30 percent of rated strength per minute to failure.
(c) Simultaneously with the mechanical load, a voltage of commercial frequency equal to 75% of the dry flashover rating shall be applied.

For illustration, see page 27.

PUNCTURE TESTS

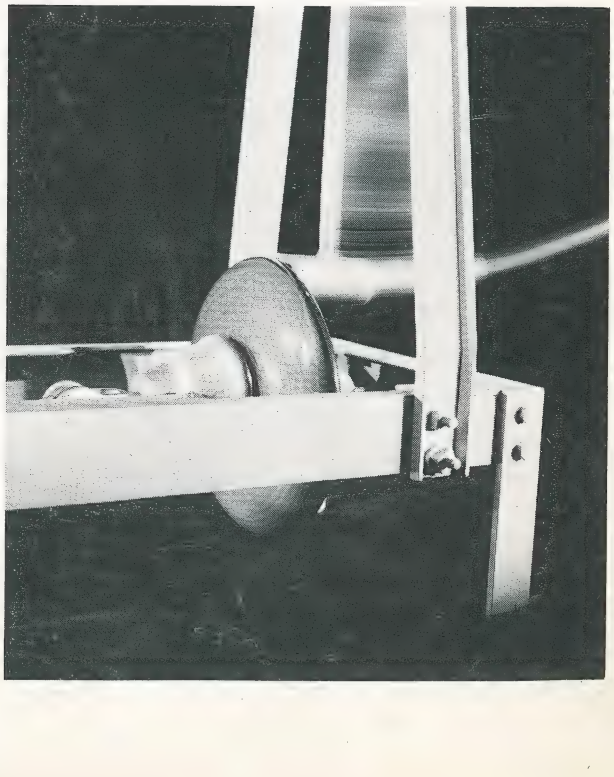
The puncture voltage is the voltage at which the tested unit will puncture. Puncture tests are performed only on fully assembled insulators. The unit is inverted and fully immersed in 6 inches of insulating oil of sufficient dielectric strength to prevent external flashover before puncture occurs. The voltage applied between cap and pin is raised to the rated dry flashover voltage of the insulator and then raised at the rate of approximately 10 KV every 15 seconds until puncture occurs.

IMPACT TESTS

The impact strength of an insulator is the blow in inch pounds which it can withstand without chipping, breaking, cracking or other damage. For this test, an impact machine illustrated below is used. (See also, page 27).

The insulator is mounted under tension of approximately 2000 lbs. A pendulum is so adjusted that when released, a copper nosed hammer will strike the outer rim of the shell squarely in a direction parallel to the axis of the unit, towards the cap. The insulator is struck a blow of specified severity in inch pounds by raising the pendulum until its shaft is opposite the corresponding inch pound mark of the indicating scale and releasing it. After receiving the blow, the unit is subjected to momentary flashover to discover any invisible damage. This test was initially introduced by Locke and is now the standard of the industry. (AIEE Standard #41-1944).

Impact test on 10″ suspension insulator.



INSULATORS

METHODS OF ESTIMATING LIGHTNING PERFORMANCE

APPLICATIONS OF THE ESTIMATING CURVES

These estimating curves from AIEE paper 50-163, Vo. 64, 1950, (committee report by AIEE working group on methods of estimating lightning performance of transmission lines) may be used to compare the relative performance of proposed transmission line designs or to determine the probable effect of modification to existing lines. The theoretical basis of the method of estimating live performance is shown in the AIEE report with which, it is assumed, the reader is familiar. The curves have been so prepared that, with the help of additional data, they may be used to estimate the actual average performance of lines. Figure 21 shows an isokeraunic map which gives the average number of thunderstorm days per year for the United States and part of Canada. The general outage probability curves are based upon 100 strokes to the line per 100 miles per year for an isokeraunic level of 30.

Three examples will be given, illustrating their use.

Example 1

A 138-kv steel tower line, shielded by an overhead ground wire, located in territory with an isokeraunic level of 50, has ten 5¾ inch spaced insulators per string. The average span is 1,000 feet and the mid-span clearance is 24 feet. The tower-footing resistances are 10 ohms for 20% of the towers and 20 ohms for 80% of the towers. What is the outage probability for this line? From Figure 15E for 1,000-foot spans, the outage probability for 10 ohms and 10 insulators is 0.7 outage per 100 miles per year. For 10 insulators and 20 ohms it is 2.8. The combined probability for strokes to tower is (0.7 x 0.2) plus (2.8 x 0.8), equals 2.38 per 100 miles per year. The permissible stroke currents for the 10 and 20 ohms are 124,000 and 79,000 amperes, respectively.

From Figure 15I the outage probability is 0.6 per 100 miles per year for 1,000-foot spans with mid-span clearance of 24 feet. The permissible stroke current is 128,000 amperes. The average of 2.38 and 0.6 is 1.49 for an isokeraunic level of 30. The outage probability for the given isokeraunic level of 50 is 50/30 times 1.49 or 2.48 outages per 100 miles per year. This computation assumes perfect shielding and would be increased to approximately 2.65 for 0.1% shielding failures.

Example 2

A 33-kv wood pole line, shielded by ground wire, located in territory with an isokeraunic level of 30 has two 5¾ inch spaced insulators per string. The minimum flashover path is the porcelain plus four feet of wood. The average span is 200 feet and the mid-span clearance eight feet. The tower-footing resistance is 50 ohms for all poles. The distance between the ground wire and bottom conductor is 10 feet at the tower. What is the outage probability for this line?

From Figure 19, four feet of wood is estimated as adding 450 kv to the insulation strength of the porcelain. Thus, the total equivalent insulation is 6.0 units. Since the spacing from ground wire to conductor is considerably less than 28 feet, an adjustment is needed to compensate for increased coupling.

From Figure 16, the correction factor for 10-foot spacing is 1.2 and the effective insulation becomes 6X1.2 equals 7.2 insulators. From Figure 15A the outage probability for 7.2 insulators and 50 ohms footing resistance is 5.4 outages per 100 miles per year. The permissible stroke current is 62,000 amperes. From Figure 15I, the outage probability for strokes to mid-span for a 200-foot span and 8-foot clearance is 0.0 per 100 miles per year and the permissible stroke current is 200,000 amperes.

Since the permissible stroke current for mid-span flashover exceeds twice that for strokes to the tower, the total outage probability should be taken from Figure 17. The permissible stroke current to a tower is 62,000 amperes, for which the total outage probability is read as 3.1 per 100 miles per year. This figure assumes that all insulator flashovers result in tripouts. Experience with such lines indicates that approximately 50 per cent of the flashovers will result in tripouts, so that the final estimate is 0.5X3.1, equals 1.6 outages per 100 miles per year for this line. This estimate assumes perfect shielding and would be increased to approximately 1.65 for 0.1% shielding failures.

Example 3

A transmission line is to be constructed in a territory where the isokeraunic level is 30. The line will be shielded by ground wire and it is desirable to insulate the line so that outages due to lightning will be limited to 2.0 per 100 miles per year. Knowledge of existing lines in the territory indicates that tower-footing resistances of 20 ohms can be obtained economically. The choice of towers and conductors calls for an average span of 800 feet. The conductors and ground wire will be sagged to provide a mid-span clearance of 18 feet. How many insulators are required to effect the desired limitation on outages?

From Figure 15 I, the outage probability for strokes to mid-span is 0.6 outage per 100 miles per year. The outage probability for strokes to tower must be 3.4 if the average is to be 2.0 per year. From Figure 15D, 8.5 insulators are required for the outage probability of 3.4 if the footing resistance is 20 ohms. Thus nine insulators should limit the outage probability to 2.0 per 100 miles per year.

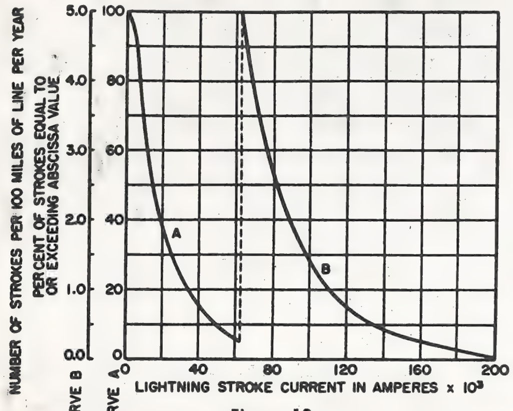


Figure 13

Figure 13
Lightning—stroke current probability curve.

Figure 14
Configuration of shielding wire and protected conductor for 0.1% exposure.

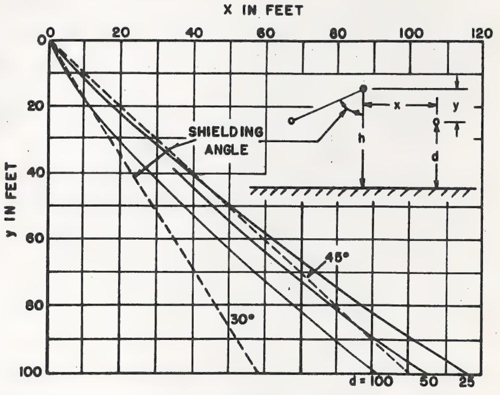


Figure 14

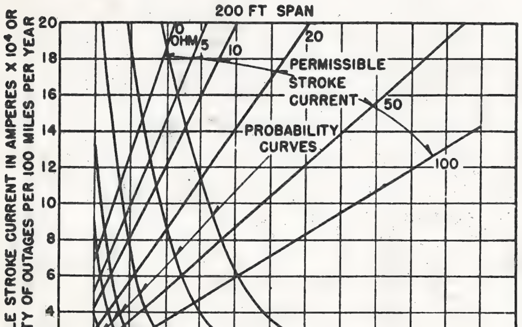


Figure 15A

Figure 15.
Curves for estimating line performance and insulation. The number of equivalent insulators is based upon 10-inch diameter 5¾-inch spaced units, and the outage probability is based on an isokeraunic level of 30 thunderstorm days per year.

INSULATORS

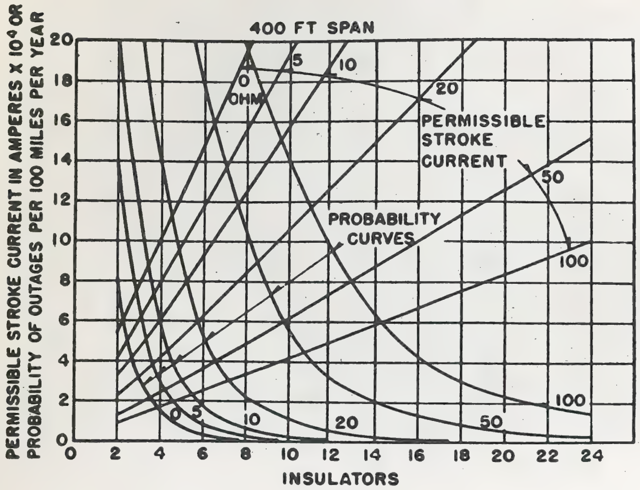


Figure 15B

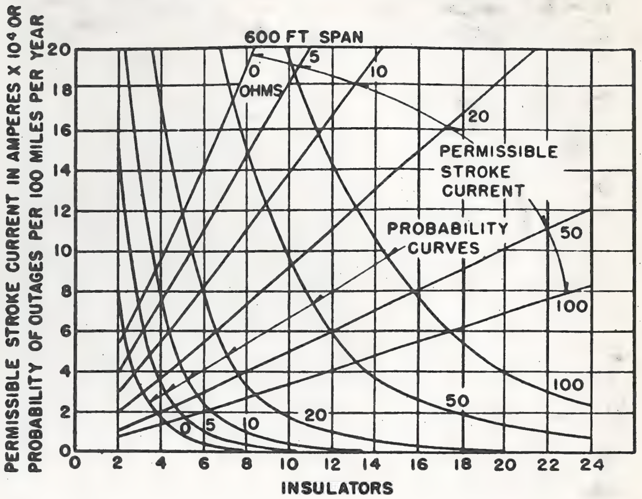


Figure 15C

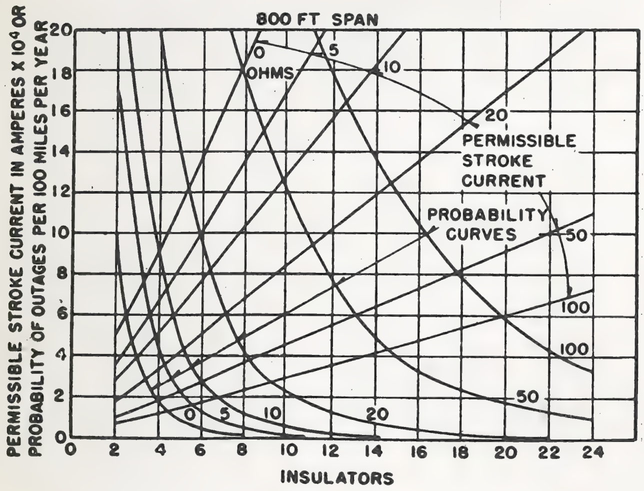


Figure 15D

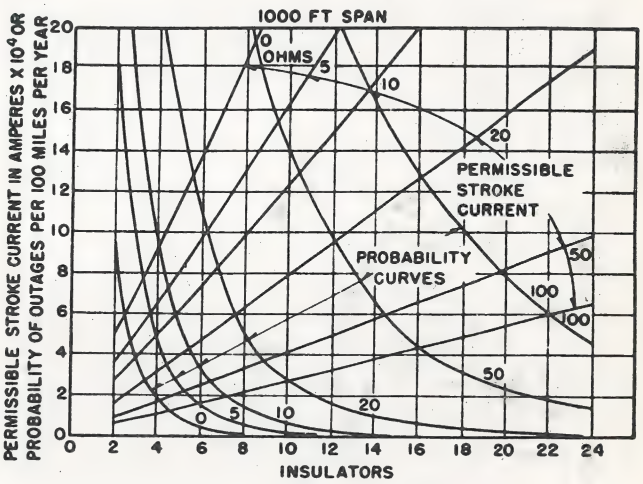


Figure 15E

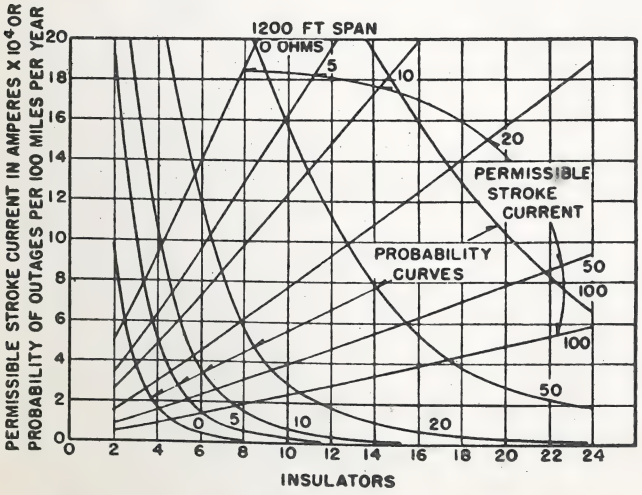


Figure 15F

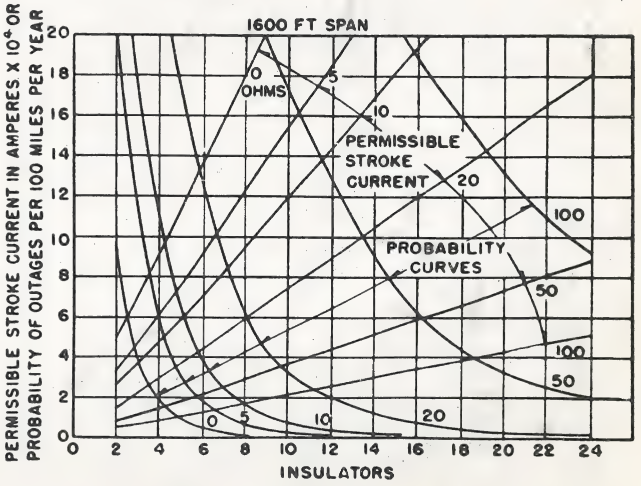


Figure 15G

METHODS OF ESTIMATING LIGHTNING PERFORMANCE (CONT.)

SUSPENSION

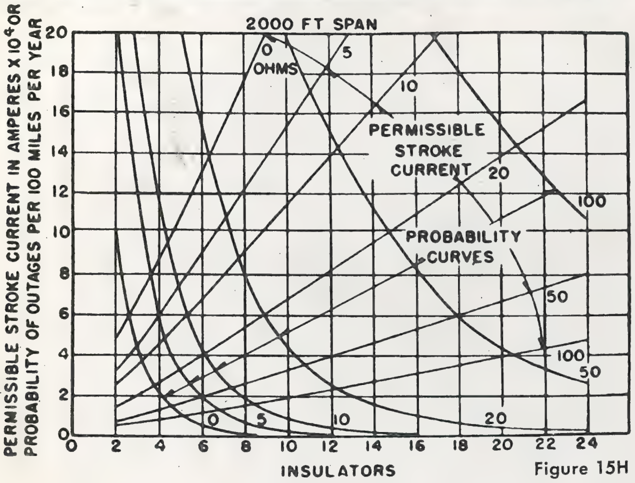


Figure 15H

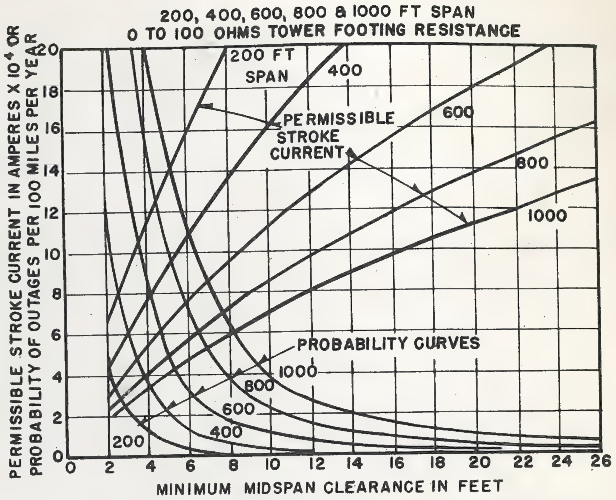


Figure 15 I

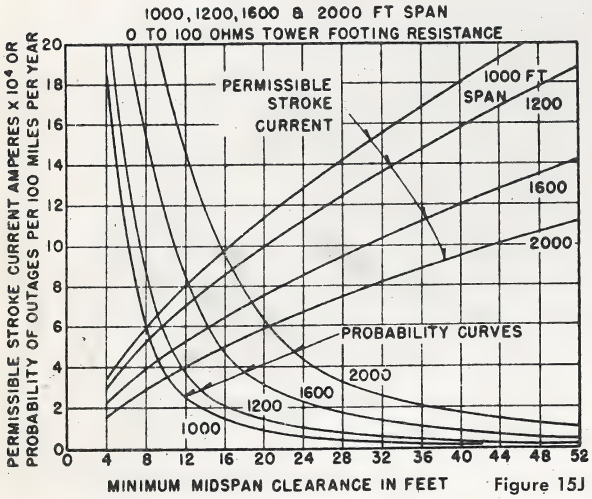


Figure 15J

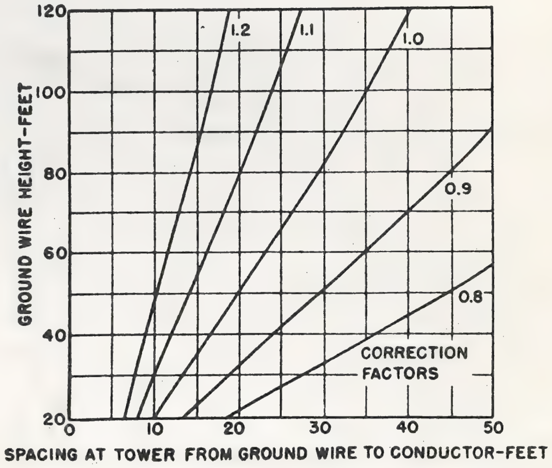


Figure 16

Figure 16.

Curve for adjusting the number of insulators when the height and spacing of conductors differ from the reference values. Multiply the actual number of insulators by the correction factor.

Figure 17.

Curve giving total outage probability when the permissible stroke current for midspan flashover exceeds twice that for tower flashover.

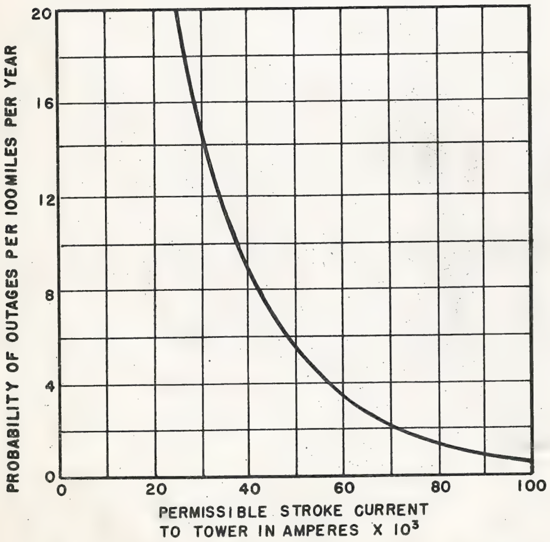


Figure 17

INSULATORS

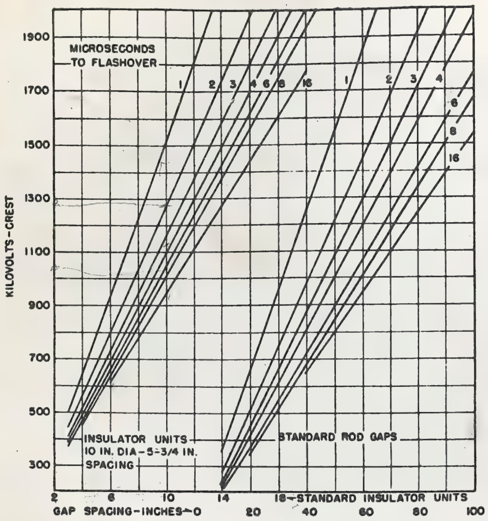


Figure 18

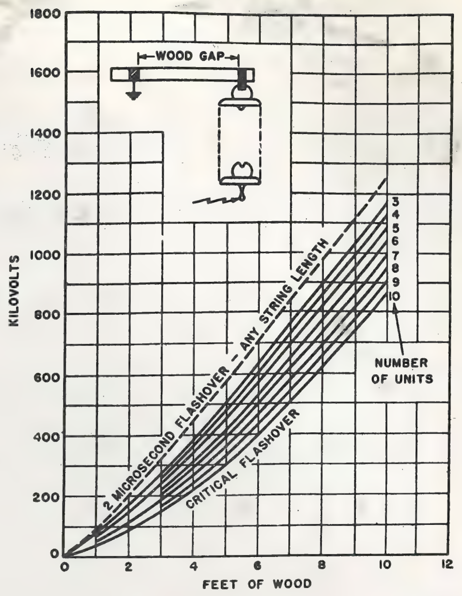


Figure19

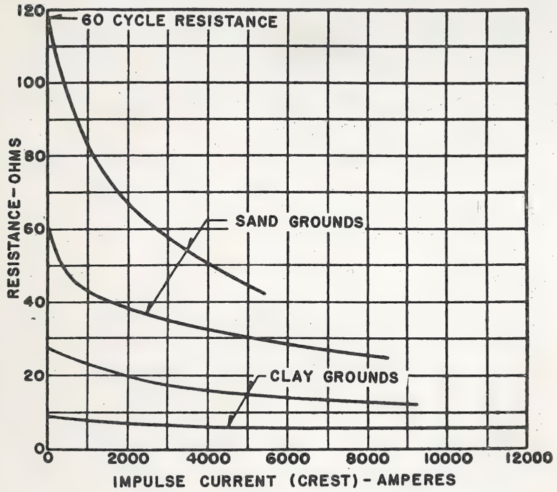
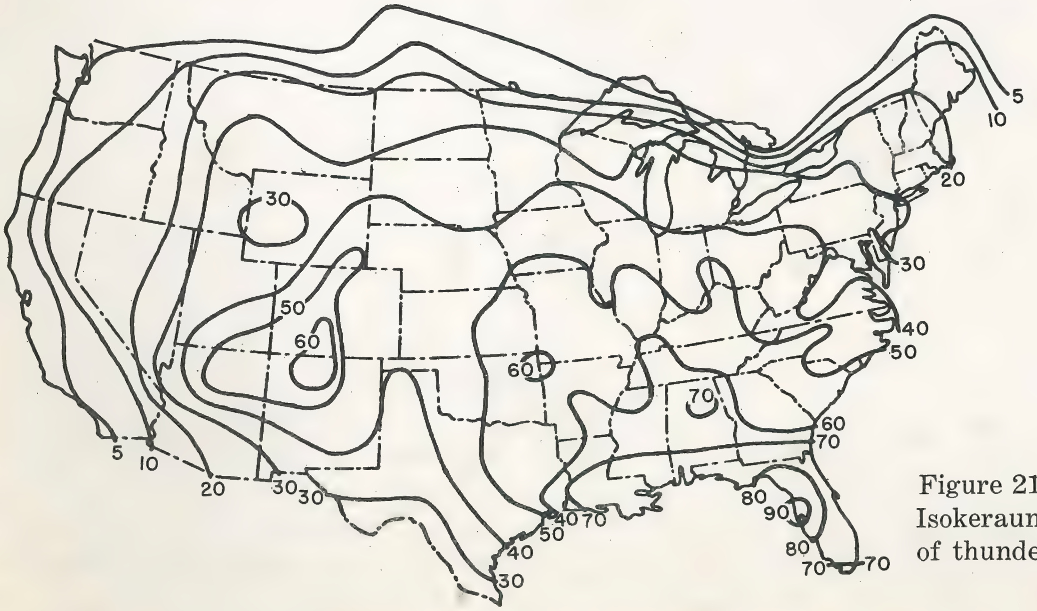


Figure 20

Figure 18.
Characteristics of insulators and rod gaps. All values are based on positive waves and corrected to standard atmospheric conditions.

Figure 19.
Impulse insulation added to insulator strings by wood. Equivalent insulators to be added may be determined from Figure 18.

Figure 20.
Effect of current on impulse resistance of driven ground rods.


5
10
20
30
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70
60
70
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70
50
40
30
80
90
80
70
70

Figure 21.
Isokeraunic map, showing number of thunderstorm days per year.

SUSPENSION

STRING FLASHOVER CHARACTERISTICS

6″ Diameter-5½″ Spacing

No. of Units	No. 16583			
	Low Frequency Flashover		Impulse Flashover 1½ x 40 MS. Wave	
	Dry KV.	Wet KV.	Pos. KV.	Neg. KV.
1	60	30	100	100
2	115	55	200	180
3	165	80	290	260

7½″ Diameter-5¾″ Spacing

No. 5875			
Low Frequency Flashover		Impulse Flashover 1½ x 40 MS. Wave	
Dry KV.	Wet KV.	Pos. KV.	Neg. KV.
65	35	115	115
125	60	210	210
180	90	300	300

Radio Influence Voltage Data	
Test KV RMS to Ground	Maximum Microvolt at 1000 Kc.
7.5	50
10	50
15	100

10″ Diameter-5″ Spacing

No. of Units	Nos. 1845 and 18405			
	Low Frequency Flashover		Impulse Flashover 1½ x 40 MS. Wave	
	Dry KV.	Wet KV.	Pos. KV.	Neg. KV.
1	80	50	125	130
2	145	85	240	235
3	200	120	335	320
4	250	155	420	395
5	300	190	495	465
6	345	225	570	535
7	390	260	645	610
8	440	295	720	680
9	485	330	790	760
10	530	365	865	840
11	575	400	935	915
12	615	435	1010	995
13	660	465	1080	1075
14	700	500	1155	1150
15	745	530	1225	1230
16	785	565	1295	1310
17	825	595	1365	1385
18	865	625	1435	1465
19	905	660	1505	1545
20	945	690	1575	1620

10″ Diameter-5¾″ Spacing

Nos. 580, 1840, 5800, 7500, 18400, 18424 and 18425			
Low Frequency Flashover		Impulse Flashover 1½ x 40 MS. Wave	
Dry KV.	Wet KV.	Pos. KV.	Neg. KV.
80	50	125	130
155	90	250	250
215	130	355	340
270	170	440	415
325	215	525	495
380	255	610	585
435	295	695	670
485	335	780	760
540	375	860	845
590	415	945	930
640	455	1025	1015
690	490	1105	1105
735	525	1185	1190
785	565	1265	1275
830	600	1345	1360
875	630	1425	1445
920	660	1505	1530
965	690	1585	1615
1010	720	1665	1700
1055	750	1745	1785

Radio Influence Voltage Data	
Test RMS to Ground	Maximum Microvolts at 1000 Kc.
10	50
25	100
40	200
50	200
60	200
70	200
80	500
85	500
90	500
95	500
NOT ASSIGNED	

LOW-FREQUENCY AND IMPULSE FLASHOVER VALUES are average and are subject to the tolerances given under paragraphs headed "Probable Variations Applying to These Tests" in ASA Standard C-29.1-1944 (Page 204).

THE RADIO INFLUENCE VALUES given apply only to new insulators tested in the factory and are the maximum microvolt ratings when tested

INSULATORS

10½″ Diameter-5¾″ Spacing (Fog Type)

No. of Units	Nos. 18135 and 18139			
	Low Frequency Flashover		Impulse Flashover 1½ x 40 MS. Wave	
	Dry KV.	Wet KV.	Pos. KV.	Neg. KV.
1	95	55	190	175
2	160	95	290	270
3	220	135	380	355
4	275	175	475	435
5	335	215	570	520
6	390	250	665	605
7	440	290	750	690
8	490	330	835	775
9	540	365	920	860
10	590	400	1005	950
11	635	435	1090	1040
12	680	465	1175	1130
13	730	500	1260	1220
14	775	535	1345	1310
15	820	570	1430	1400
16	865	605	1515	1490
17	910	635	1600	1585
18	955	670	1685	1670
19	1000	705	1770	1755
20	1040	735	1850	1840

10½″ Diameter-6½″ Spacing (Fog Type)

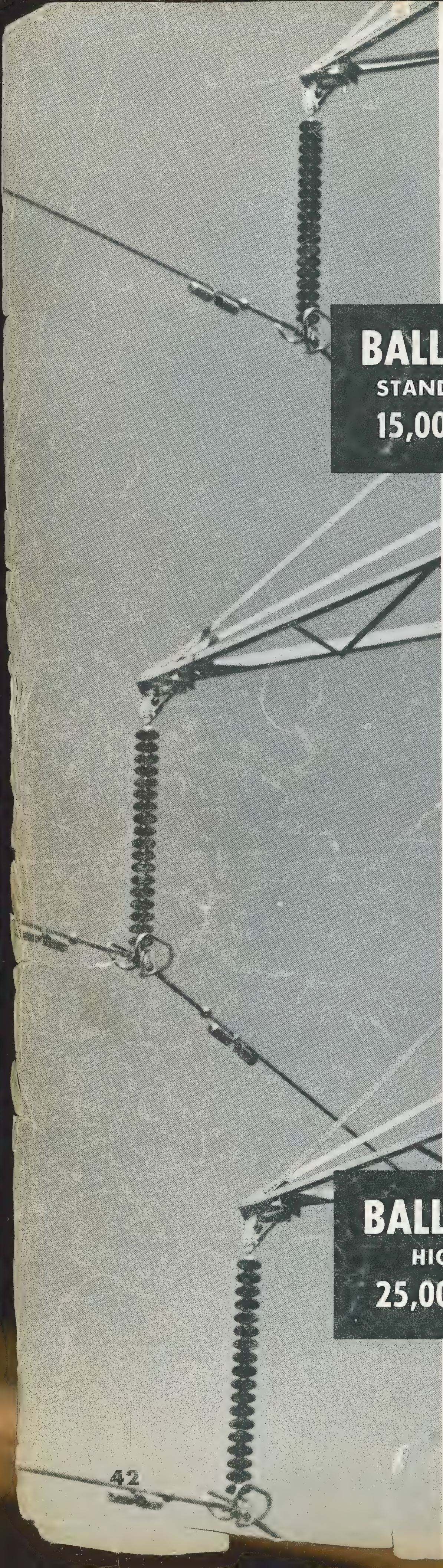
No. of Units	Nos. 18134, 18136, 18138 and 18144				Radio Influence Voltage Data	
	Low Frequency Flashover		Impulse Flashover 1½ x 40 MS. Wave			
	Dry KV.	Wet KV.	Pos. KV.	Neg. KV.	Test KV RMS. to Ground	Maximum Microvolts at 1000 Kc
1	100	60	195	180	10	50
2	175	105	305	290	25	100
3	240	145	420	390	40	200
4	305	190	525	475	50	200
5	365	235	625	565	60	200
6	425	275	720	665	70	200
7	480	315	815	760	80	500
8	540	360	910	865	85	500
9	595	400	1010	965	90	500
10	650	440	1105	1070	95	500
11	700	480	1200	1170	NOT ASSIGNED	
12	755	520	1300	1270		
13	805	560	1395	1375		
14	855	595	1490	1475		
15	905	635	1585	1580		
16	955	670	1680	1680		
17	1005	710	1770	1780		
18	1055	750	1865	1880		
19	1105	785	1960	1980		
20	1150	820	2050	2085		

12″ Diameter-7″ Spacing

No. of Units	No. 15000				Radio Influence Voltage Data	
	Low Frequency Flashover		Impulse Flashover 1½ x 40 MS. Wave			
	Dry KV.	Wet KV.	Pos. KV.	Neg. KV.	Test KV. RMS. to Ground	Maximum Microvolts at 1000 Kc.
1	95	55	155	160	10	50
2	180	100	305	275	25	100
3	250	145	415	380	40	200
4	315	185	520	480	50	200
5	380	225	620	580	60	200
6	440	270	725	680	70	200
7	505	310	825	785	80	500
8	565	350	925	890	85	500
9	620	390	1025	995	90	500
10	680	435	1120	1105	95	500
	No. 15000 Cont'd.					
11	735	475	1220	1210		
12	790	515	1315	1315		
13	840	550	1410	1420		
14	895	590	1510	1525		
15	950	625	1605	1630		
16	1005	665	1700	1740		
17	1055	705	1795	1845		
18	1110	740	1885	1950		
19	1160	775	1975	2050		
20	1210	810	2065	2150		

at the indicated test voltage to ground. The tests are made in accordance with the current NEMA-EEI-RMA recommendations on methods of measuring radio noise, NEMA Publications No. 107, and ASA Standard C-29.1-1944 (Page 204). The low frequency RMS test voltage values are approximately 10% higher than the line to ground voltage at which these insulators are usually operated.

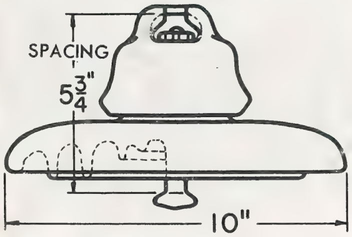
MICRO
SUSPENSION



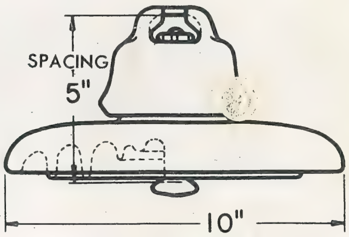
BALL & SOCKET
STANDARD STRENGTH
15,000 LBS. M & E

The dependability of these units, proven over long years of service, makes them the preferred standard of most suspension insulator users. They are universally adaptable to most conditions. The 25,000 lbs. unit can often be used instead of yokes, when suspending heavy lines on long spans, river crossings or for dead-ending where high strength is needed.

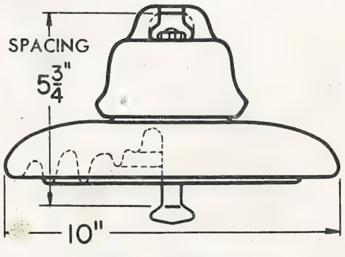
Nos. 18400 and 18405 differ from Nos. 1840 and 1845 by their extra heavy porcelain shells which increase their impact strength for maximum resistance to



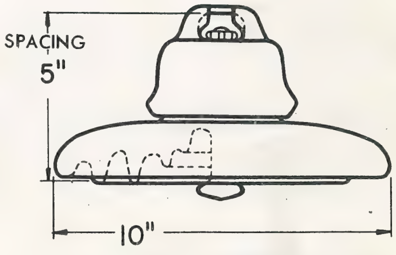
NO. 1840
JOINT EEI-NEMA STD.



NO. 1845

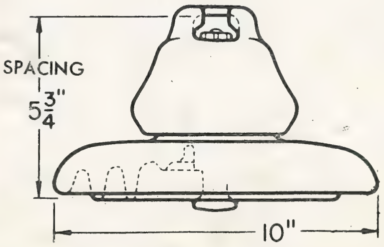


NO. 18400



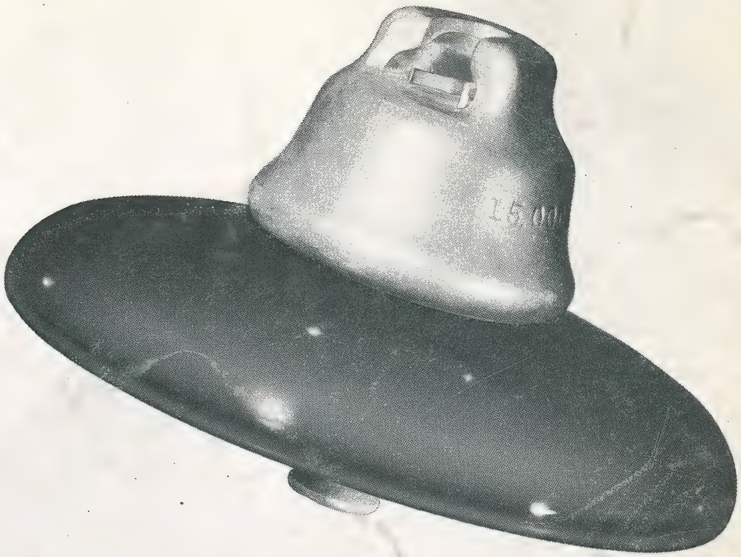
NO. 18405

BALL & SOCKET
HIGH STRENGTH
25,000 LBS. M & E



NO. 18425
JOINT EEI-NEMA STD.

GLAZE INSULATORS



damage from rocks, bullet[illegible]and other blows.

Maximum load for these units should not exceed one half their rated M. & E. strength.

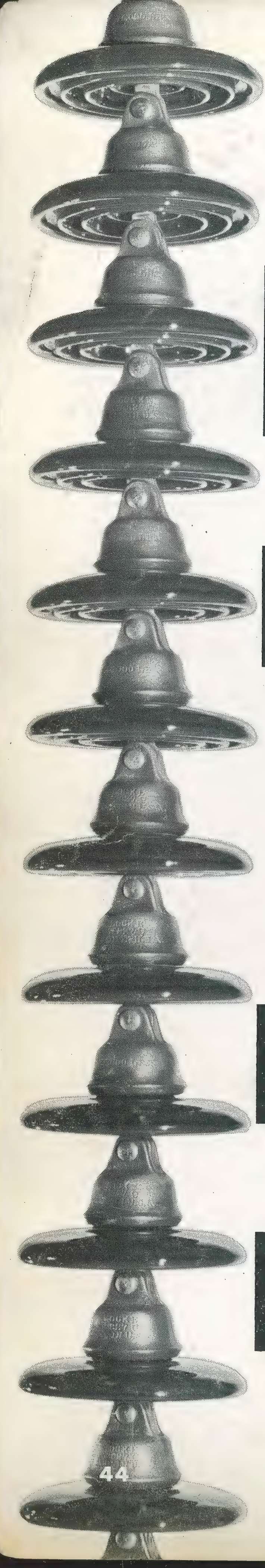
Ball bolts are galvanized forged steel, caps are galvanized steel or malleable iron. Cotter pins are high grade copper alloy.

For further information on Microglaze insulators, see page 10.

Catalog Number	EEI NEMA Class	Max. Load Lbs.	Impact Strength Inch-Lbs.	Leakage Distance Inches	Flashover—KV				Dry Arcing Dist. to Std. Clevis or Socket Fitting	Radio Influence Voltage		Approx. Lbs. Each		Std. Pkg. Quan.
					Low Frequency		Impulse 1 ½ x 40 MS Wave			Test KV RMS to Ground	Max. Micro-volt at 1000 Kc	Net	Pkd.	
					Dry	Wet	Pos.	Neg.						
1840	52-3	7500	55	11½	80	50	125	130	7½	10	50	11	12½	6
1845	—	7500	55	11½	80	50	125	130	7 ⅜	10	50	11	12½	6
18400	—	7500	90	11½	80	50	125	130	7½	10	50	12½	14	6
18405	—	7500	90	11½	80	50	125	130	7½	10	50	12½	14	6
18425*	52-5	12500	60	11	80	50	125	130	7½	10	50	15	17	6

For String Data, see Pages 40-41.

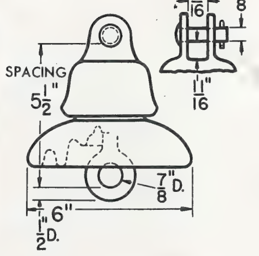
*In No. 18425, the slot in the top of the socket accommodates a ball neck diameter of approx. ¾". The neck diameter of the ball bolt is 23/32". This makes the unit not completely interchangeable with 25,000 lbs. or 15,000 lbs. ball and socket units previously furnished. Where such interchangeability is desired, order No. 18424. Maximum recommended working load of No. 18424 is 10,000 lbs., compared with 12,500 lbs. of 18425. All ball and socket end fittings have been modified to couple properly with either No. 18425 or 18424.



MICRO
SUSPENSION

CLEVIS TYPE

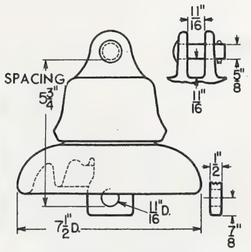
STANDARD STRENGTH
10,000 LBS. M & E



SPACING
5 1/2"
11/16"
5/8"
11/16"
7/8" D.
6"
1/2" D.

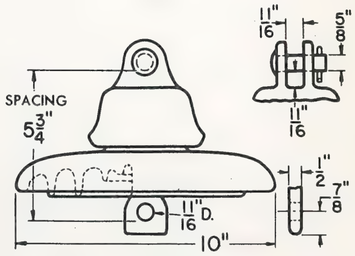
NO. 16583
JOINT EEI-NEMA STD.

STANDARD STRENGTH
15,000 LBS. M & E



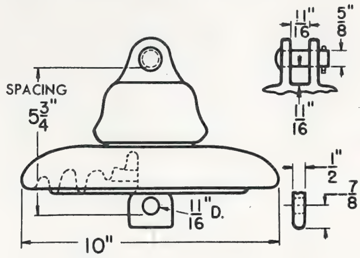
SPACING
5 3/4"
11/16"
5/8"
11/16"
1/2"
11/16" D.
7 1/2" D.
7/8"

NO. 5875
JOINT EEI-NEMA STD.



SPACING
5 3/4"
11/16"
5/8"
11/16"
1/2"
7/8"
11/16" D.
10"

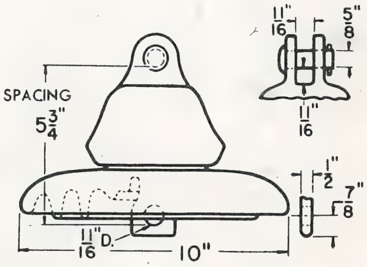
NO. 580
JOINT EEI-NEMA STD.



SPACING
5 3/4"
11/16"
5/8"
11/16"
1/2"
7/8"
11/16" D.
10"

NO. 5800

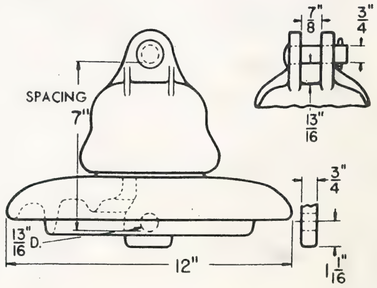
HIGH STRENGTH
25,000 LBS. M & E



SPACING
5 3/4"
11/16"
5/8"
11/16"
1/2"
7/8"
11/16" D.
10"

NO. 7500
JOINT EEI-NEMA STD.

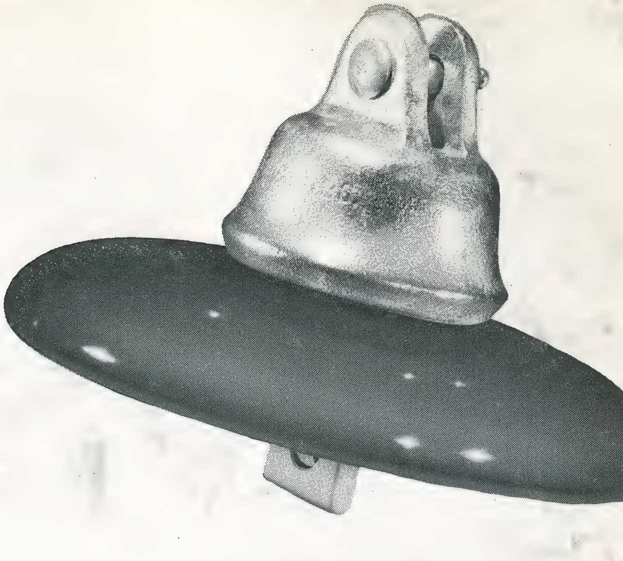
EXTRA HIGH STRENGTH
36,000 LBS. M & E



SPACING
7"
7/8"
3/4"
13/16"
3/4"
13/16" D.
12"
1 1/16"

NO. 15000
JOINT EEI-NEMA STD.

GLAZE INSULATORS



These units are preferred standard with most insulator users, where clevis type suspension insulators are desired.

No. 16583 is ideal for dead-ending and angles on distribution circuits up to 13 KV, ungrounded. It may also be used as a single insulator dead-end at low voltage and in strings for higher voltages. No. 5875 replaces 16583 for higher conductor tensions and where higher flashover values are desired.

Nos. 7500 and 15000 can often be used instead of yokes when suspending heavy lines on long spans, river crossings, or for dead-ending where high strength is needed.

No. 5800 differs from No. 580 by its extra heavy porcelain shell which increases its impact strength for maximum resistance to damage from rocks, bullets and other blows.

Maximum load for these units should not exceed one half their rated M. & E. strength.

Clevis bolts are galvanized forged steel, caps are galvanized steel or malleable iron. Cotter pins in the clevis bolt are high grade copper alloy and are of the humped type, self-locking, to simplify hot line work.

For further information on Microglaze insulators, see page 10.

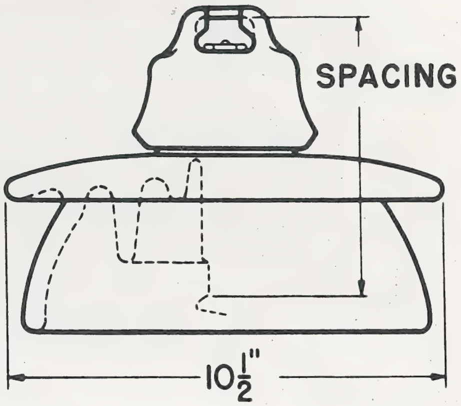
Catalog Number	EEI NEMA Class	Max. Load Lbs.	Impact Strength Inch-Lbs.	Leakage Distance Inches	Flashover—KV				Dry Arcing Dist. to Std. Clevis or Socket Fitting	Radio Influence Voltage		Approx. Lbs. Each		Std. Pkg. Quan.
					Low Frequency		Impulse 1½ x 40 MS Wave			Test KV RMS to Ground	Max. Micro-volt at 1000 Kc	Net	Pkd.	
					Dry	Wet	Pos.	Neg.						
16583	52-1	5000	45	7	60	30	100	100	4⅛	7.5	50	5¼	5¾	12
5875	52-2	7500	50	8¼	65	35	115	115	5½	7.5	50	8	9	8
580	52-4	7500	55	11½	80	50	125	130	7½	10	50	11	12½	6
5800	—	7500	90	11½	80	50	125	130	7¾	10	50	12½	14	6
7500	52-6	12500	60	11	80	50	125	130	7½	10	50	15	17	6
15000	52-7	18000	50	12½	95	55	155	160	—	10	50	25	30	6

For String Data, see Pages 40-41.

MICRO
FOG-TYPE SUSPENSION

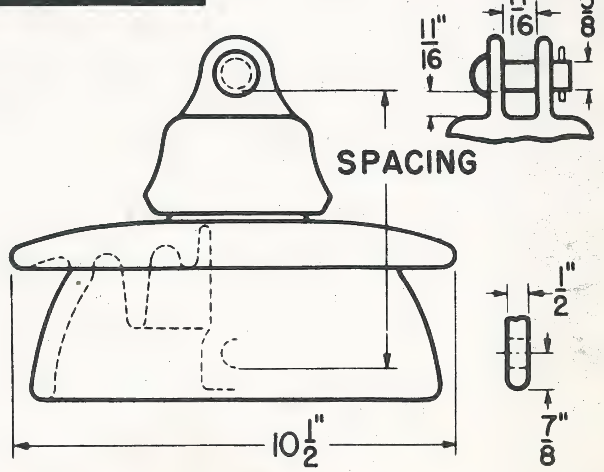
Note deep corrugations on easily reached protected under side of Locke Fog-Type Microglaze Insulators.

BALL & SOCKET
15,000 LBS.


SPACING
10 1/2"

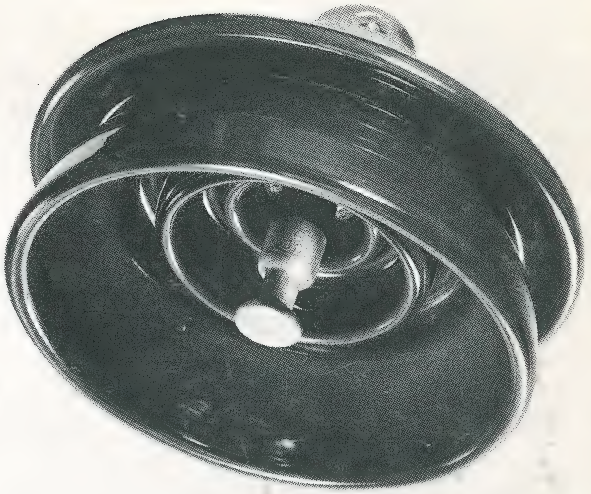
NOS. 18134 TO 18139

CLEVIS TYPE
15,000 LBS.


11/16"
11/16"
5/8"
SPACING
1/2"
7/8"
10 1/2"

NOS. 18136 AND 18144

GLAZE
INSULATORS



The new Locke fog-type suspension insulator is specially designed for operation in areas where heavy fog, salt spray or industrial contamination demand maximum ratio of *effective* leakage distance to string length. Its service advantages include long protected leakage distance, increased impact strength, wide spacing between units, reduced net weight and excellent radio influence characteristics. For further details, see page 33.

Maximum load for these units should not exceed one half their rated M. & E. strength.

Catalog Number	Spacing Inches	Impact Strength Inch-Lbs.	Leakage Distance Inches	Flashover—KV				Dry Arcing Dist. to Std. Clevis or Socket Fitting	Radio Influence Voltage		Approx. Lbs. Each		Std. Pkg. Quan.
				Low Frequency		Impulse 1½ x 40MS Wave			Test KV RMS to Ground	Max. Micro-volt at 1000 Kc	Net	Pkd.	
				Dry	Wet	Pos.	Neg.						
18134	6½	55	17	100	60	195	180	10¼	10	50	15½	17	5
18135	5¾	55	17	95	55	190	175	10	10	50	15½	17	5
***18138**	6½	55	17	100	60	195	180	10¼	10	50	15½	17	5
***18139**	5¾	55	17	95	55	190	175	10	10	50	15½	17	5
18136	6½	55	17	100	60	195	180	10¼	10	50	15½	17	5
***18144**	6½	55	17	100	60	195	180	10¼	10	50	15½	17	5

For string data, see pages 40–41.

*Nos. 18138, 18139 and 18144 are furnished with high-strength, corrosion resistant bronze bolts for use in extremely corrosive atmospheres.

EEI-PUB. NO. TDJ-52
NEMA PUB. NO. 140-1952

EEI-NEMA

SUSPENSION TYPE

1. SCOPE

1.1 These standards cover 6-inch diameter and larger, standard corrugated, suspension-type insulators made of wet-process porcelain used in the transmission and distribution of electrical energy.

2. DEFINITIONS

2.1 See Section 2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof, for definition of terms. (Page 204)

3. GENERAL

3.1 Standard insulators shall conform in all respects to the requirements hereinafter stated. The text, data sheets, and data sheet drawings supplement each other and shall be considered as parts of these standards.

3.2 The data sheet drawings are type drawings, and over-all dimensions are shown.

3.3 Manufacturer's drawings, if furnished, shall show the outline of the insulators together with all pertinent dimensions. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

4. MATERIAL

4.1 The insulators shall be made of good commercial grade wet-process porcelain.

4.2 The entire porcelain surface of the insulators that will be exposed after assembly shall be glazed. The standard color of the glaze shall be brown. The entire surface shall be relatively free from imperfections.

4.3 Metal parts, except for cotter pins, shall be made of a good commercial grade of malleable iron or open hearth or electric furnace steel, galvanized in accordance with *ASTM Specifications for Zinc Coating (Hot Dip) on Iron and Steel Hardware,** Publication No. A 153-49, or latest revision thereof. Cotter pins shall be made of a material of suitable corrosion resistance and temper.

5. DIMENSIONS AND CHARACTERISTICS

5.1 Dimensions and characteristics shall be in accordance with the data sheets.

6. MARKING

6.1 Each insulator unit shall bear symbols identifying the manufacturer, the year of manufacture and the rated combined M & E strength. The markings shall be legible and durable.

7. PACKING

7.1 Insulators shall be so packed as to prevent injury to them during transportation and handling. Insulators packed in containers conforming to all construction requirements of Consolidated Freight classifications as to bursting tests, size limit and gross weight shall be considered as being adequately packed.

7.2 Each box or container shall be marked with the number of pieces contained therein, the catalogue number, or drawing number, or description of the contents, and the manufacturer's name.

8.MANUFACTURER'S PRODUCTION SAMPLING AND TESTS

8.1 The manufacturer shall make adequate tests to determine that insulators manufactured in accordance with these standards will meet the requirements thereof.

9. SAMPLING, INSPECTION AND TESTS

9.1 **General.** Substantial test experience, over a long period of time, indicates that a total of ½ of one per cent of the number of insulators in a lot is sufficient to establish characteristics demonstrable by destructive tests.

9.2 **Dimensions.** Three insulators shall be selected at random from the lot and their dimensions checked against the dimensions on the manufacturer's drawing. Failure of more than one of the insulators to conform, within manufacturing tolerances, to the dimensions on this drawing shall constitute failure of the lot to meet this standard.

9.3 **Design Tests.** Certified test data on insulators of existing design shall be regarded as equivalent to actual design tests. Design tests on insulators of new design shall be made in accordance with paragraphs 9.3.1 through 9.3.5.

9.3.1 **Low-frequency Dry-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.1 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average dry-flashover value of the three insulators to equal or exceed 95 per cent of the rated dry-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.2 **Low-frequency Wet-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average wet-flashover value of the three insulators to equal or exceed 90 per cent of the rated wet-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.3 **Critical-impulse Flashover — Positive and Negative.** Three insulators shall be selected at random for the critical-impulse flashover, positive, and three for the critical-impulse flashover, negative, and tested in accordance with Section 4.3 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average of the critical-impulse flashover value of the three insulators to equal or exceed 92 per cent of the rated critical-impulse flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.4 **Radio-influence Voltage.** Five insulators shall be selected at random and tested in accordance with Section 4.5 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. If one or more insulators fail to meet the requirements given on the applicable data sheet, five additional insulators shall be selected at random and tested. Failure of one or more of these additional insulators shall constitute failure to meet this standard.

9.3.5 **Time Loading.** If a time-loading test is required, five assembled insulators shall be selected at random and tested in accordance with Section 5.3 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. The rated time-loading value as given on the applicable data sheet shall be maintained for 24 hours. If one or more insulators fail to meet the requirements given on the applicable data sheet, five additional insulators shall be selected at random and tested. Failure of one or more of these additional insulators shall constitute failure to meet this standard.

9.4 **Quality Control Tests**

9.4.1 **Visual.** Conformity with paragraph 4.2 may be determined by visual inspection. All insulators not conforming to paragraph 4.2 fail to meet this standard.

9.4.2 **Porosity.** Test specimens shall be selected from insulators destroyed in other tests and tested in accordance with Section 5.4 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Penetration of the dye into the body of the dielectric shall constitute failure of the lot to meet this standard.

9.4.3 **Galvanizing.** Five pieces representative of each type of hardware used with the insulators shall be selected at random before assembly and tested in accordance with Section 6.1 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of more than one specimen to withstand six (except for cotter bolts which require only four) one-minute copper sulphate dips [see *ASTM Method of Test for Uniformity of Coating by the Preece Test (Copper Sulphate Dip) on Zinc-coated (Galvanized) Iron or Steel Articles,* Publication No. A 239-41] shall constitute failure of the lot to meet this standard.

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*Copies are available from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

9.4.4 Routine Flashover. Each insulator shall be subjected to a routine flashover test in accordance with paragraph 7.1.1 or 7.1.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. All insulators which puncture fail to meet this standard.

9.4.5 Thermal Shock. Five insulators shall be selected at random and tested in accordance with Section 5.5 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. If one or more insulators fail, five additional insulators shall be selected at random from the same lot and tested. Failure of one or more of these additional insulators shall constitute failure of the lot to meet this standard.

9.4.6 Tension Proof Test. Each assembled insulator shall be given a proof test in tension in accordance with paragraph 7.2.1 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. The load applied shall be that shown on the applicable data sheet. All insulators which fail do not meet this standard.

9.4.7 Impact Tests. Three assembled insulators shall be selected at random and tested in accordance with paragraph 5.1.2.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. If one or more insulators fail to meet the requirements given in the applicable data sheet, three additional assembled insulators shall be selected at random from the same lot and tested. Failure of one or more of the additional insulators shall constitute failure of the lot to meet this standard.

9.5 Quality Control Tests—Statistical Sampling

9.5.1 Definitions of Symbols. The symbols used in the following paragraphs are as follows:

$\bar{X}$ —Average value obtained on the sample of five insulators tested.
$\bar{X}_L$—Lower limit for the average of the five insulators tested.
$\bar{X}_U$—Upper limit for the average of the five insulators tested.
R —Range from the highest to the lowest value obtained on the sample of five insulators tested.
$\bar{R}$ —Average range.

NOTE—A manufacturer shall establish and submit limits before the test and may select any values of $\bar{X}_L$, $\bar{X}_U$ and $\bar{R}$, provided such values satisfy the requirements of paragraphs 9.5.2 and 9.5.3.

9.5.2 Combined Mechanical and Electrical Strength Tests. Five assembled insulators shall be selected at random and tested in accordance with paragraph 5.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. The criteria for determining conformance to this standard are:

$\bar{X}_L$ equal to or greater than rating plus 0.25 $\bar{R}$.
$\bar{X}_U$ equals $\bar{X}_L$ plus 1.16 $\bar{R}$.
R equal to or less than 2.1 $\bar{R}$.

If $\bar{X}$ of the sample falls below $\bar{X}_L$ or above $\bar{X}_U$ or if the range of the sample is greater than 2.1 $\bar{R}$, this shall constitute failure of the lot to meet this standard.

9.5.3 Puncture Tests. Five assembled insulators shall be selected at random and tested in accordance with Paragraph 4.7 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. The oil used in this test shall have a breakdown voltage of not less than 12.5 KV when measured in accordance with paragraphs 22, 23 and 24 of the *ASTM Methods of Testing Electrical Insulating Oils,* Publication No. D 117-50, or latest revision thereof. The criteria for determining conformance to this standard are:

$\bar{X}_L$ equal to or greater than 0.9 times rating plus 0.4 $\bar{R}$.
$\bar{X}_U$ equals $\bar{X}_L$ plus 1.16 $\bar{R}$.
R equal to or less than 2.1 $\bar{R}$.

If $\bar{X}$ of the sample falls below $\bar{X}_L$ or above $\bar{X}_U$ or if the range of the sample is greater than 2.1 $\bar{R}$, this shall constitute failure of the lot to meet this standard.

BALL GAGES

for Class 52-3 Insulator

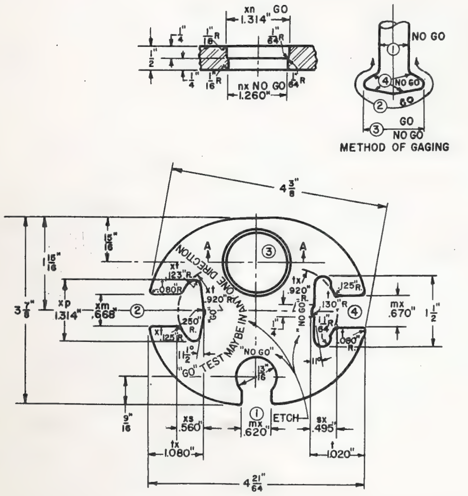

xn GO
1.314"
1/4"
1/2"
1/16"R
1/64"R
nx NO GO
1.260"
NO GO
①
④ NO GO
② GO
③ GO
NO GO
METHOD OF GAGING
4 3/8"
3 7/8"
1 15/16"
15/16"
A
③
ONE DIRECTION
"GO" TEST MAY BE IN ANY
xt .123"R.
.080"R
xt .920"R
xp 1.314"
xm .668"
②
.250" R.
xt .125"R
11 1/2°
"GO"
"NO GO"
13/16"
tx .920" R.
"NO GO"
1/4"
.125"R.
.130"R
11/64"R
④
.080" R.
11°
mx .670"
1 1/2"
9/16"
xs .560"
①
mx .620"
ETCH
sx .495"
tx 1.080"
t 1.020"
4 21/64"

Figure A

for Class 52-5 Insulator

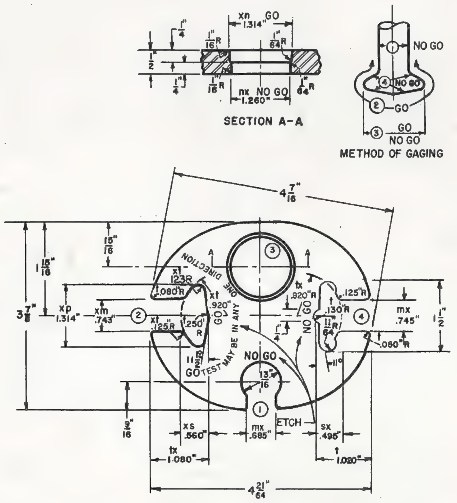

xn GO
1.314"
1/4"
1/2"
1/16"R
1/64"R
nx NO GO
1.260"
SECTION A-A
NO GO
①
④ NO GO
② GO
③ GO
NO GO
METHOD OF GAGING
4 7/16"
3 7/8"
1 15/16"
15/16"
A
③
ONE DIRECTION
GO TEST MAY BE IN ANY
xt 123R
.080"R
xt .920"
GO
xp 1.314"
xm .743"
②
xt .125R
.250" R
11 1/2°
NO GO
13/16"
tx .920"R
NO GO
1/4"
.125"R
.130"R
11/64"R
④
mx .745"
1 1/2"
.080"R
11°
9/16"
xs .560"
①
mx .685"
ETCH
sx .495"
tx 1.080"
t 1.020"
4 21/64"

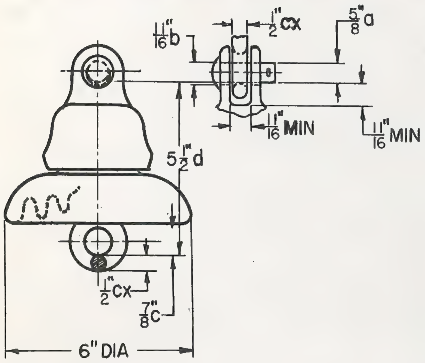
Figure C

NOTE I—"No-Go" test must be for all directions; "Go" test may be in any one direction.

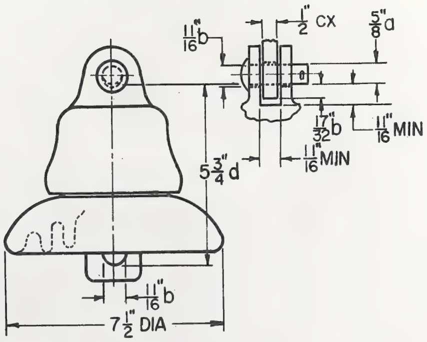
NOTE II—Tolerances
m=0.0002 inch
n=0.001 inch
p=0.002 inch
r=0.003 inch
s=0.004 inch
t=0.005 inch
x=0.0000 inch

The use of a single letter indicates the same plus or minus tolerance, for example, m=plus or minus 0.0002 inch. Where two letters are used, the first indicates the plus tolerance and the second indicates the minus tolerance, for example, mx=plus 0.0002 inch, minus 0.0000 inch.

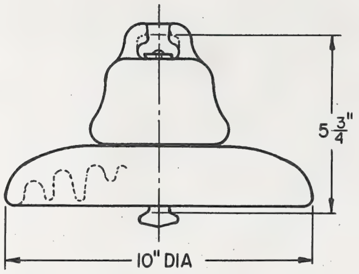
SUSPENSION TYPE CONT.



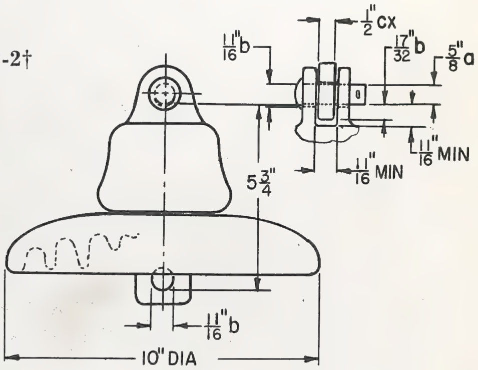
Class 52-1†



Class 52-2†



Class 52-3*



Class 52-4†

Characteristics	Class 52-1	Class 52-2	Class 52-3	Class 52-4	Paragraph In Pub. No. C29.1-1944
1. DIMENSIONS					
a. Leakage Distance, Inches	7	8¼	11½	11½	2.6.1
2. MECHANICAL VALUES					
a. Combined M & E Strength, Pounds	10000	15000	15000	15000	5.2
b. Mechanical Impact Strength, Inch-Pounds	45	50	55	55	5.1.2.2
c. Routine Proof Test Load, Pounds	4000	6000	6000	6000	7.2.1
d. Time Load Test Value, Pounds	6000	10000	10000	10000	5.3
3. ELECTRICAL VALUES					
a. Low-frequency Dry Flashover, Kv	60	65	80	80	4.1
b. Low-frequency Wet Flashover, Kv	30	35	50	50	4.2
c. Impulse Flashover—Postive, Kv	100	115	125	125	4.3
d. Impulse Flashover—Negative, Kv	100	115	130	130	4.3
e. Low-frequency Puncture Voltage, Kv	80	90	110	110	4.7
4. RADIO INFLUENCE VOLTAGE DATA					
a. Low-frequency Test Voltage—Rms to Ground, Kv	7.5	7.5	10	10	4.5
b. Maximum Radio Influence Voltage—Microvolts at 1000 Kilocycles	50	50	50	50	4.5

*Dimensions and tolerances to be determined after galvanizing by ball and socket gages shown in Figures A and B, pages 49 and 51, respectively. The connecting hardware parts defined by gages shown on Figures A and B are designated as Type B.

†Tolerances apply after galvanizing.

NOTE I—The connecting length of a string of six insulators selected at random shall be equal to six times the nominal spacing of the insulators plus or minus ½ inch.

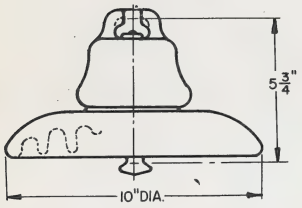
NOTE II—Tolerances

a=1/64 inch	d=⅛ inch	g=⅜ inch
b=1/32 inch	e=3/16 inch	h=½ inch
c=1/16 inch	f=¼ inch	x=0 inch

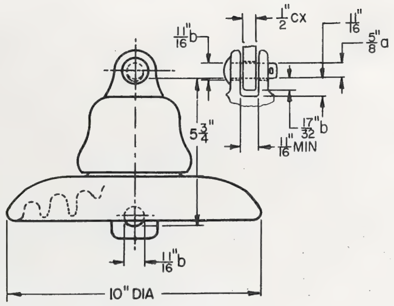
The use of a single letter indicates the same plus or minus tolerance, for example, a=plus or minus 1/64 inch. Where two letters are used, the first indicates the plus tolerance and the second indicates the minus tolerance, for example, ax=plus 1/64 inch, minus 0 inch.

STANDARDS

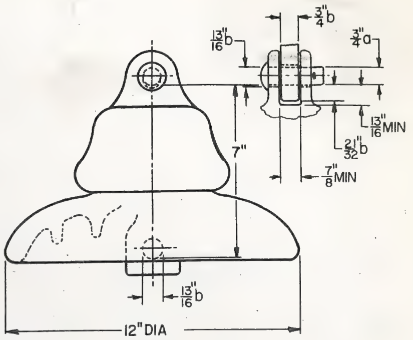
FOR WET PROCESS PORCELAIN INSULATORS


$5\frac{3}{4}$"
10" DIA.

Class 52-5*


$\frac{11}{16}$"b
$\frac{1}{2}$"cx
$\frac{1}{16}$"
$\frac{5}{8}$"a
$5\frac{3}{4}$"
$\frac{17}{32}$"b
$\frac{11}{16}$"MIN
$\frac{11}{16}$"b
10" DIA

Class 52-6


$\frac{3}{4}$"b
$\frac{13}{16}$"b
$\frac{3}{4}$"a
7"
$\frac{13}{16}$"MIN
$\frac{21}{32}$"b
$\frac{7}{8}$"MIN
$\frac{13}{16}$"b
12" DIA

Class 52-7

Characteristics	Class 52-5	Class 52-6	Class 52-7	Paragraph In Pub. No. C29.1-1944
1. DIMENSIONS				
a. Leakage Distance, Inches	11	11	12½	2.6.1
2. MECHANICAL VALUES				
a. Combined M & E Strength, Pounds	25000	25000	36000	5.2
b. Mechanical Impact Strength, Inch-Pounds	60	60	50	5.1.2.2
c. Routine Proof Test Load, Pounds	10000	10000	14400	7.2.1
d. Time Load Test Value, Pounds	15000	15000	20000	5.3
3. ELECTRICAL VALUES				
a. Low-frequency Dry Flashover, Kv	80	80	95	4.1
b. Low-frequency Wet Flashover, Kv	50	50	55	4.2
c. Impulse Flashover—Positive, Kv	125	125	155	4.3
d. Impulse Flashover—Negative, Kv	130	130	160	4.3
e. Low-frequency Puncture Voltage, Kv	110	110	130	4.7
4. RADIO INFLUENCE VOLTAGE DATA				
a. Low-frequency Test Voltage—Rms to Ground, Kv	10	10	10	4.5
b. Maximum Radio Influence Voltage—Microvolts at 1000 Kilocycles	50	50	50	4.5

*Dimensions and tolerances to be determined after galvanizing, by ball and socket gages shown in Figures C and D on page 49 and below. The connecting hardware parts, defined by gages shown in Figures C and D are designated as Type J.

NOTE I—The connecting length of a string of six insulators selected at random shall be equal to six times the nominal spacing of the insulators plus or minus ½ inch.

NOTE II—Tolerances apply after galvanizing.

NOTE III—Tolerances

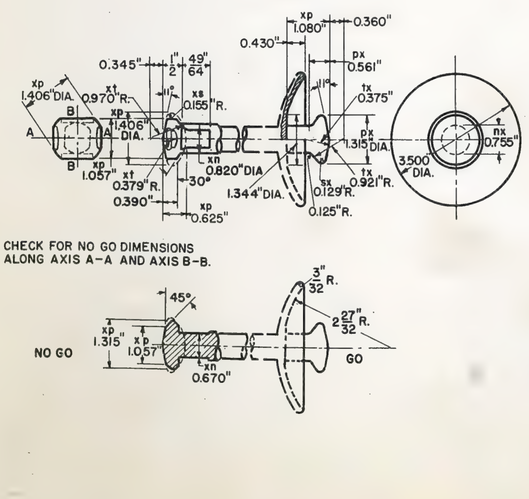
a=1/64 inch
b=1/32 inch
c=1/16 inch
d=⅛ inch
e=3/16 inch
f=¼ inch
g=⅜ inch
h=½ inch
x=0 inch

The use of a single letter indicates the same plus or minus tolerance, for example, a=plus or minus 1/64 inch. Where two letters are used, the first indicates the plus tolerance and the second indicates the minus tolerance, for example, ax=plus 1/64 inch, minus 0 inch.

SOCKET GAGES

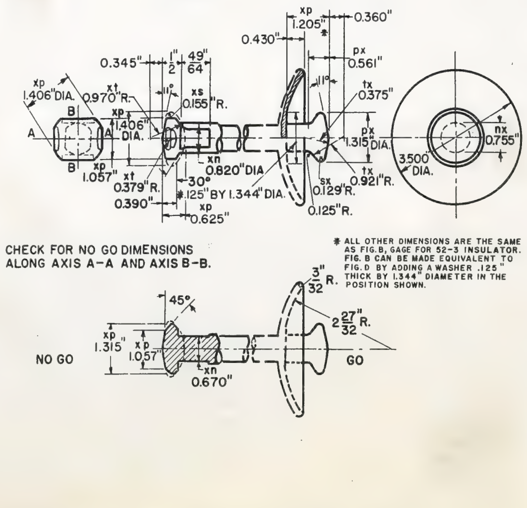
for Class 52-3 Insulator

Figure B


xp 1.080"
0.360"
0.430"
0.345"
$\frac{1}{2}$"
$\frac{49}{64}$"
px 0.561"
xp 1.406" DIA.
xt 0.970" R.
11°
xs 0.155" R.
tx 0.375"
B
A
xp 1.406" DIA.
px 1.315" DIA.
nx 0.755"
3.500 DIA.
xn 0.820" DIA
1.057"
xt 0.379" R.
0.390"
30°
1.344" DIA.
sx 0.129" R.
tx 0.921" R.
0.125" R.
xp 0.625"
CHECK FOR NO GO DIMENSIONS ALONG AXIS A-A AND AXIS B-B.
45°
$\frac{3}{32}$" R.
$2\frac{27}{32}$" R.
NO GO
xp 1.315"
xp 1.057"
xn 0.670"
GO

for Class 52-5 Insulator

Figure D


xp 1.205"
0.360"
0.430"
0.345"
$\frac{1}{2}$"
$\frac{49}{64}$"
px 0.561"
xp 1.406" DIA.
xt 0.970" R.
11°
xs 0.155" R.
tx 0.375"
B
A
xp 1.406" DIA.
px 1.315" DIA.
nx 0.755"
3.500 DIA.
xn 0.820" DIA
1.057"
xt 0.379" R.
0.390"
30°
*.125" BY 1.344" DIA.
sx 0.129" R.
tx 0.921" R.
0.125" R.
xp 0.625"
CHECK FOR NO GO DIMENSIONS ALONG AXIS A-A AND AXIS B-B.
45°
$\frac{3}{32}$" R.
$2\frac{27}{32}$" R.
NO GO
xp 1.315"
xp 1.057"
xn 0.670"
GO

* ALL OTHER DIMENSIONS ARE THE SAME AS FIG. B, GAGE FOR 52-3 INSULATOR. FIG. B CAN BE MADE EQUIVALENT TO FIG. D BY ADDING A WASHER .125" THICK BY 1.344" DIAMETER IN THE POSITION SHOWN.

NOTE I—Tolerances

m=0.0002 inch
n=0.001 inch
p=0.002 inch
r=0.003 inch
s=0.004 inch
t=0.005 inch
x=0.0000 inch

The use of a single letter indicates the same plus or minus tolerance, for example, m=plus or minus 0.0002 inch. Where two letters are used, the first indicates the plus tolerance and the second indicates the minus tolerance, for example, mx=plus 0.0002 inch, minus 0.0000 inch.

SUSPENSION AND

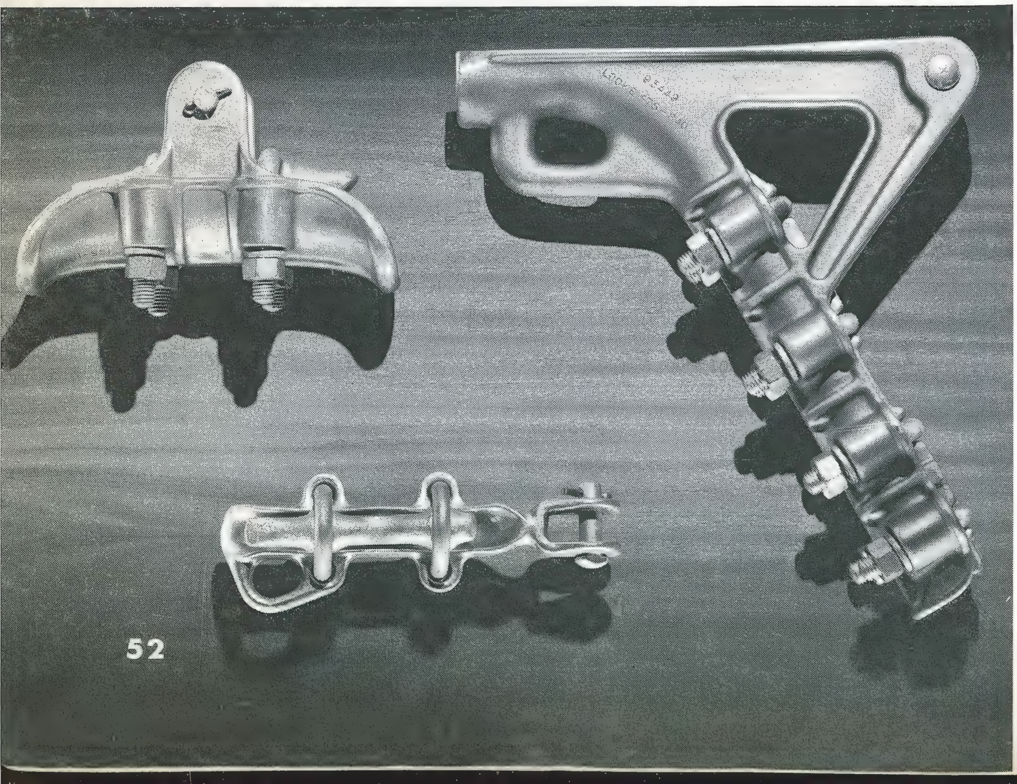
Locke markets a complete line of suspension and strain clamps for modern transmission lines. They are made of aluminum, forged steel or malleable iron, selected for their excellent elongation properties and freedom of season cracking. Careful control of manufacture avoids cracks, shrink and projecting fins or flash.

SUSPENSION CLAMP DESIGN

To eliminate conductor damage, Locke suspension clamps are of conventional envelope design with U-Bolts. They comply with cable manufacturers' recommendations, assuring proper seating without forcing or pinching cable strands and armor rods. The conductor is firmly supported in its smooth seat and prevented from bending too sharply where it is held by the keeper and at the lips of the clamp. Even under severe operating conditions, wide take-off-angles are accommodated without bending the conductor over a small radius at any point in contact with the clamp. In addition, clamp body and keeper are designed to support the conductor uniformly around its circumference.

STRAIN CLAMP DESIGN

Locke strain clamps are of the quadrant or trunnion type with accelerated wave seat, high ultimate strength and with holding power at least 90% of the rated breaking strength of the largest conductor within the clamp range. Installation is easy and is facilitated by guides on the keepers which assure positive seating. Keepers exert pressure on the conductor through tightening of independent U-Bolts. These provide maximum holding power without injuring keeper or clamp when sufficient torque to flatten lock washers has been applied.



Locke suspension and strain clamps such as the aluminum alloy clamps shown here, are widely used in transmission and distribution systems. They incorporate modern design features for ease of installation and hot line handling.

STRAIN CLAMPS

ALUMINUM ALLOY CLAMPS
REDUCE ENERGY LOSSES

With loads of 200 Amperes or more on transmission or sub-transmission lines, significant reductions in energy losses will pay for the additional cost of aluminum clamps within a few years after installation. Suspension and strain clamps surround the alternating current carrying conductor and act similar to a short circuited secondary of a transformer. As the current increases, losses in ferrous clamps of high magnetic permeability increase at a rate, almost proportional to the square of the current.

Currents set up a magnetic field around the conductor through which they flow. Iron and other ferromagnetic parts close to or in actual contact with the conductor become strongly magnetized. In 60 cycle systems this field reverses its direction 120 times a second, setting up hysteresis and eddy current losses in iron and steel parts. These losses are in the form of heat.

In aluminum parts, hysteresis losses caused by the molecular friction are completely eliminated. Eddy currents which constitute the remainder of the total heating loss, are caused by the continually varying magnetic field set up by alternating currents, inducing voltages in clamp parts and causing circulating currents to flow in the clamp. While they also occur in aluminum parts, the lower resistivity of aluminum reduces the energy loss (I^2R). Figure 22 shows a comparison of power losses in aluminum and ferrous clamps.

On heavily loaded lines, the temperature rise of ferrous clamps frequently limits the load to which the line can be subjected, due to conductor temperature limitations at the points of support. Where aluminum alloy clamps are used, temperature rise at the points of support is universally lower than at other points in the span. For this reason, aluminum alloy clamps have found wide application in the construction of heavily loaded high voltage lines.

The lower power dissipation in aluminum clamps and consequent reduction in temperature rise results in favorable reduction of the corrosion rate, compared to iron or forged steel under similar conditions. This temperature rise, compared to line current is shown in Figure 23 for aluminum and ferrous clamps. High operating temperature, caused by hysteresis and eddy currents in malleable iron and forged steel clamps, can damage the conductor by annealing. Aluminum keepers are standard with Locke aluminum clamps to avoid the effect of galvanic corrosion.

For details on aluminum alloy, see page 12.

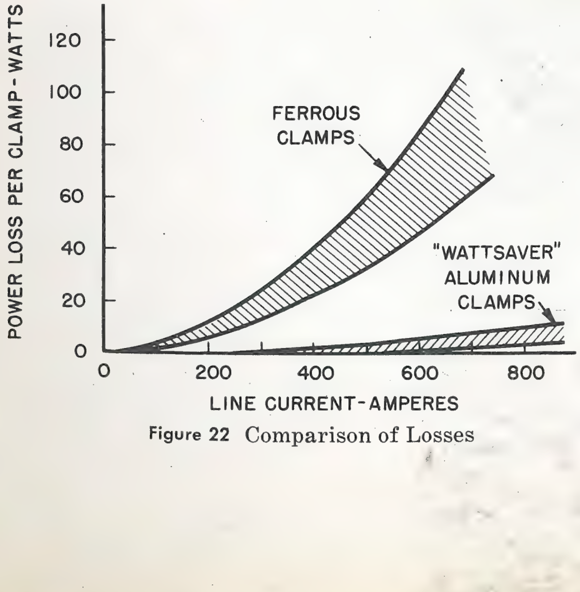


Figure 22 Comparison of Losses

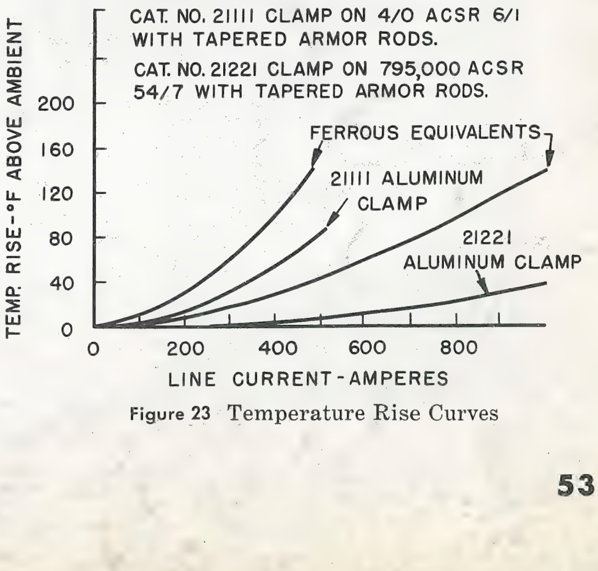
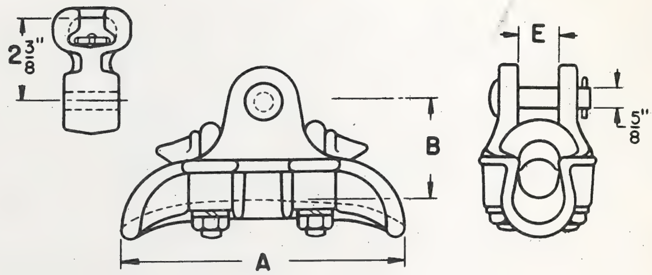


Figure 23 Temperature Rise Curves

SUSPENSION

ALUMINUM ALLOY



These clamps are recommended for use with all-aluminum conductor or ACSR—bare or over armor rods. Liners are not needed.

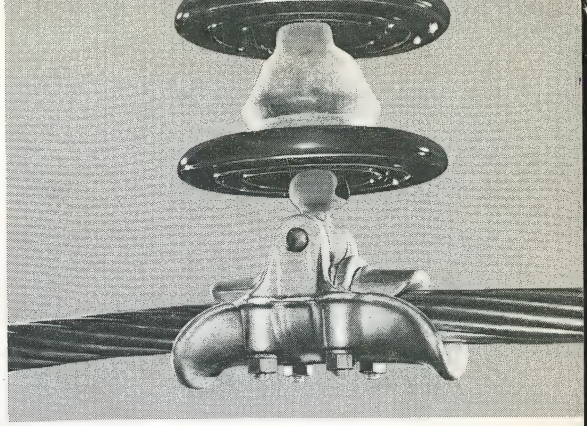
Bodies and keepers are made of special aluminum alloy, selected for high strength and corrosion resistance. Connectors, bolts, nuts, lockwashers and pins are galvanized ferrous parts.

For reduction of energy losses with these clamps, see page 53. Low losses, and the clamp's increased heat radiating surface assure lower conductor temperature at support points than in the span. Higher loads can be carried without exceeding maximum safe conductor temperatures or encountering loss of strength and fatigue resistance in the conductor.

Select clamps for as snug a fit as possible. Clamp groove diameter should not be over 15% greater than diameter of conductor or armor rods, if used. For clamp recommendations, see pages 66-73.

Catalog Number			Dimensions—Inches					Ult. Strength Lbs.	Approx. Lbs. per C				Clamp Recom. Ref.
Socket Connector	Clevis Connector	No Connector	Cable Diam.		A	B	E		Socket or Clevis Con.		No Connector		
			Min.	Max.					Net	Pkd.	Net	Pkd.	
21103	21102	21101	.50	1.00	8	2⅝	1 1/16	25000	430	445	325	340	1
21113	21112	21111	.625	1.15	8	2¾	1 3/16	25000	480	495	375	390	2
21123	21122	21121	.85	1.27	8½	2⅞	1 5/16	25000	540	580	410	440	3
21143	21142	21141	1.00	1.45	9	3⅛	1 9/16	25000	615	645	475	505	4
21163	21162	21161	1.10	1.60	10	3¼	1 11/16	25000	640	670	500	530	5
21183	21182	21181	1.25	1.80	10	3½	1⅞	25000	750	800	575	625	6
21203	21202	21201	1.40	2.00	10½	3¾	2⅛	25000	855	905	680	730	7
21223	21222	21221	1.75	2.25	11	4	2⅜	25000	1065	1120	855	940	8
21253	21252	21251	2.00	2.50	12	4½	2⅝	25000	1195	1255	1000	1060	9

CLAMPS

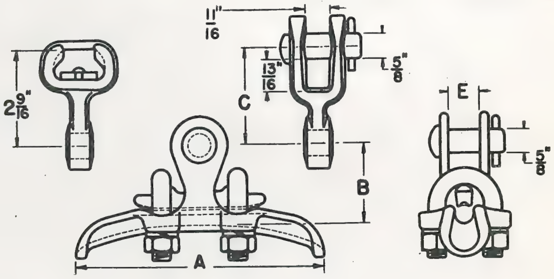


Aluminum Alloy Suspension Clamp

FORGED STEEL

Connectors, bodies and keepers are made of drop forged SAE 1038 Steel. Cotter bolts are galvanized, high strength, heat treated steel. Cotter keys are copper alloy. These clamps are provided with U-Bolts.

Aluminum or copper liners can be furnished at slight extra cost. Specify by adding AL or CL to catalog number. Standard .050″ liners reduce groove diameter by .100″.



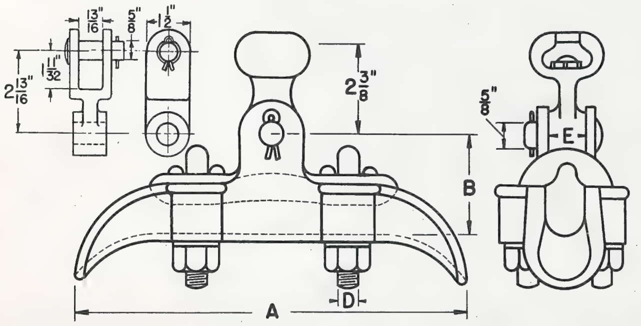
Select clamps for as snug a fit as possible. Clamp groove diameter should not be over 15% greater than diameter of conductor or armor rods, if used. For clamp recommendations, see pages 66-73.

Catalog Number			Dimensions—Inches						Ult. Strength Lbs.	Approx. Lbs. per C				Clamp Recom. Ref.
Socket Connector	Clevis Connector	No Connector	Cable Diam.		A	B	C	E		Socket or Clevis Con.		No Connector		
			Min.	Max.						Net	Pkd.	Net	Pkd.	
46200A	46230A	46240A	.125	.460	6½	2⅛	2½	⅞	15000	315	325	215	225	10
46201A	46231A	46241A	.312	.600	6½	2⅛	2½	⅞	17000	320	330	220	230	11
46251A	46261A	46271A	.187*	.600*	6½	2⅛	2½	⅞	17000	325	335	225	235	12
46202A	46232A	46242A	.50	.700	7¼	2 5/16	2½	1⅛	18000	420	430	315	325	13
46203A	46233A	46243A	.50	.830	7¼	2 5/16	2½	1⅛	18000	430	440	325	335	14
46204A	46234A	46244A	.625	1.000	8	2 7/16	2¾	1¼	22000	480	495	375	390	15
46205A	46235A	46245A	.625	1.150	8	2 7/16	2¾	1¼	22000	490	505	385	400	16
46255A	46265A	46275A	.850	1.270	9½	2⅞	2¾	1⅝	25000	630	660	475	505	17
46206A	46236A	46246A	1.125	1.375	9½	2⅞	2¾	1⅝	25000	640	670	485	515	18
46257A	46267A	46277A	1.125	1.450	9½	2⅞	2¾	1⅝	25000	650	680	495	525	19
46207A	46237A	46247A	1.125	1.600	9½	2⅞	2¾	1⅝	25000	665	695	510	540	20
46208A	46238A	46248A	1.375	1.800	10¼	3⅛	2¾	2	25000	955	1005	780	830	21
46209A	46239A	46249A	1.375	2.000	10¼	3⅛	2¾	2	25000	980	1030	805	855	22
46210A	46280A	46290A	1.625	2.250	12	4	2¾	2¼	25000	1140	1195	950	1005	23
46211A	46281A	46291A	1.625	2.500	12	3 15/16	2¾	2½	25000	1230	1290	1040	1100	24

* Reversible two-groove keeper accommodates wide range of cable sizes.

SUSPENSION CLAMPS

MALLEABLE IRON



Connectors, bodies and keepers are made of galvanized malleable iron. Cotter bolts and U-Bolts are galvanized steel. Lips at end of body are curved to accommodate take-off angle up to 23 degrees without causing any sharp bend in the conductor. Cotter keys are copper alloy. Aluminum or copper liners can be furnished at slight extra cost. Specify by adding AL or CL to catalog number. Standard .050″ liners reduce groove diameter by .100″.

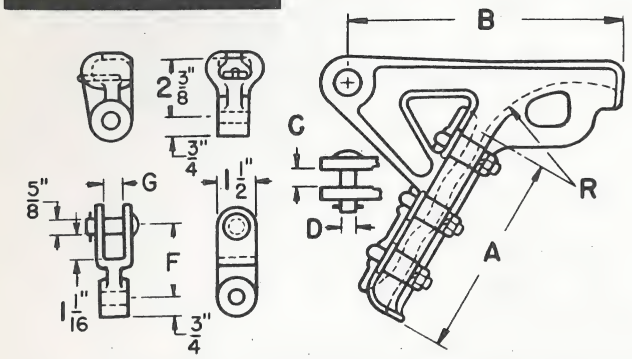
Select clamps for as snug a fit as possible. Clamp groove diameter should not be over 15% greater than diameter of conductor or of armor rods, if used. For clamp recommendations, see pages 66-73.

Catalog Number			Dimensions—Inches						Ult. Strength Lbs.	Approx. Lbs. per C, Pkd.		Clamp Recom. Ref.
Socket Connector	Clevis Connector	No Connector	Cable Diam.		A	B	D	E		Socket or Clevis Conn.	No Connector	
			Min.	Max.								
A1101	A1201	A1301	.20	.46	5¾	2⅛	½	19/32	16000	300	213	25
A1103	A1203	A1303	.30	.60	7	2¼	½	11/16	16000	334	263	26
A1105	A1205	A1305	.30	.70	7	2¼	½	25/32	18000	375	288	27
A1107	A1207	A1307	.40	.82	7½	2⅜	½	15/16	18000	425	325	28
A1109	A1209	A1309	.50	1.00	8	2⅜	⅝	1 1/16	25000	*500	437	29
A1111	A1211	A1311	.70	1.15	8	2½	⅝	1¼	25000	**600	525	30
A11115	A12115	A13115	.85	1.27	8½	2⅝	9/16	1⅜	25000	650	500	31
A1113	A1213	A1313	.80	1.38	8¾	2¾	⅝	1 15/32	25000	725	575	32
A1115	A1215	A1315	.90	1.45	9	2⅞	⅝	1 9/16	25000	763	600	33
A1117	A1217	A1317	1.00	1.60	10	3	⅝	1 11/16	25000	900	750	34
A1119	A1219	A1319	1.20	1.80	10	3¼	⅝	1⅞	25000	1025	850	35
A1121	A1221	A1321	1.30	2.00	10½	3½	⅝	2 1/16	25000	1200	1025	36
A1123	A1223	A1323	1.50	2.25	11	3¾	⅝	2⅜	25000	1400	1225	37

* For No. A1209, this value is 487.
** For No. A1211, this value is 587.

STRAIN CLAMPS

ALUMINUM ALLOY



These clamps are recommended for use with all-aluminum conductor or A.C.S.R.. Liners are not needed.

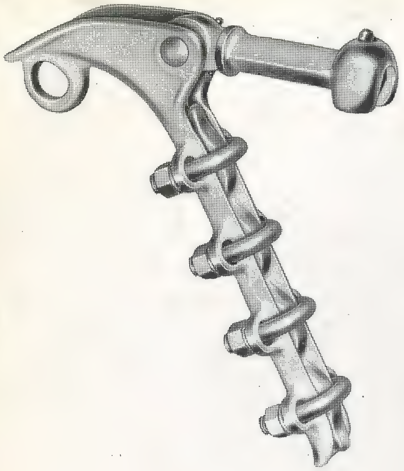
A new feature of the clamps shown on this page is very important for hot line maintenance of strain insulator strings. Previous designs made no provision for stable seating of the nose or span end of the clamp in hot line strain carriers, used in hot line maintenance of strain strings. Interference with stable support was met with the come-along attachment eye. In the new clamps shown here, the come-along attachment eye has been set back from the end. The nose of the clamp gives firm, stable support in the strain carrier.

Bodies and keepers are made of special aluminum alloy, selected for high strength and corrosion resistance. Connectors, bolts, nuts, lockwashers and pins are galvanized ferrous parts.

For reduction of energy losses with these clamps, see page 53. Low losses and the clamp's increased heat radiating surface assure lower conductor temperature at support points than in the span. Higher loads can be carried without exceeding maximum safe conductor temperatures or encountering loss of strength and fatigue resistance in the conductor.

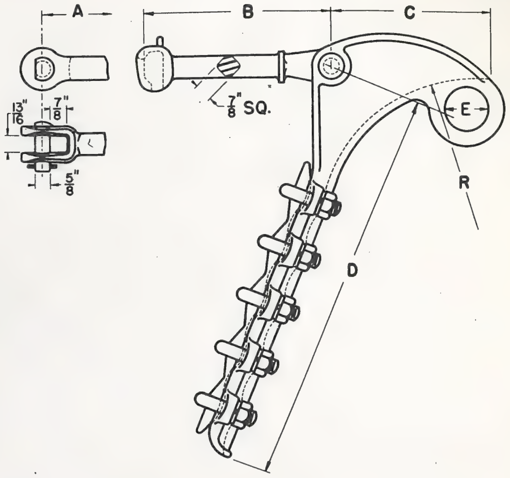
Select clamps for as snug a fit as possible. Clamp groove diameter should not be over 15% greater than conductor diameter. For clamp recommendations, see pages 66-73.

Catalog Number	Connector	Dimensions—Inches									No. of U-Bolts	No. Keeper Pcs.	Ult. Strength Lbs.	Approx. Lbs. per C		Clamp Recom. Ref.
		Cable Diam. Min.	Cable Diam. Max.	A	B	C	D	F	G	R				Net	Pkd.	
21435 **21433** **21437**	Socket Clevis None	.200	.550	7½	10⅞	⅝	⅝	2 13/16	13/16	3¾	3	1	15000	550 550 450	575 575 475	38
21440 **21640** **21442**	Socket Clevis None	.300	.680	9½	11⅞	¾	⅝	2 13/16	13/16	4¾	4	2	20000	775 775 650	825 825 700	39
21445 **21645** **21447**	Socket Clevis None	.475	.840	12	12⅞	⅞	⅝	2 13/16	13/16	5½	4	2	23000	1200 1200 1075	1250 1250 1100	40
21450 **21650** **21452**	Socket Clevis None	.500	.960	13	13⅞	1	⅝	2 13/16	13/16	6	5	2	25000	1350 1350 1200	1400 1400 1250	41
21455 **21654** **21457**	Socket Clevis None	.710	1.100	16	16⅞	1 3/16	¾	2⅜	11/16	7½	5	2	27000 27000 30000	1900 1900 1700	1950 1950 1750	42
21460 **21656** **21462**	Socket Clevis None	.750	1.280	20	18⅞	1 5/16	¾	2⅜	11/16	8	6	3	27000 27000 30000	2300 2300 2100	2375 2375 2175	43



FORGED STEEL

STRAIN



Connectors, bodies and keepers are made of drop forged SAE 1038 Steel. Cotter bolts are galvanized, high strength, heat treated steel. Cotter keys are copper alloy.

These clamps are for use with copper, Copperweld, ACSR and Amerductor conductors. Nos. 45040 and 45050 have ribbed seats in clamp body and keeper —especially designed for dead-ending steel, Copperweld or other high strength cables.

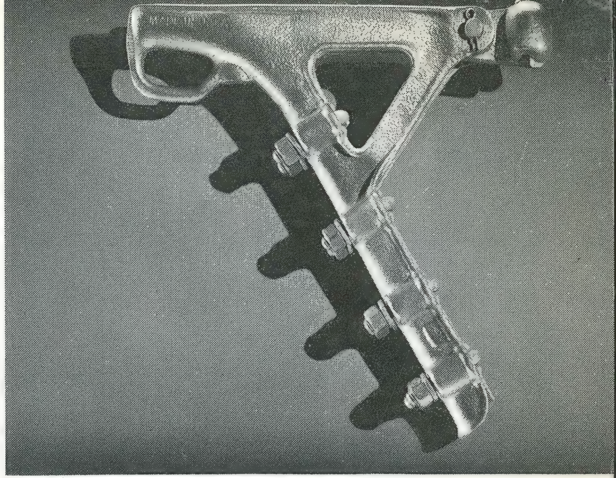
Aluminum or copper liners can be furnished at slight extra cost. Specify by adding AL or CL to catalog number. Standard .050″ liners reduce groove diameter by .100″.

For clamp recommendations, see pages 66-73.

Catalog Number		Dimensions—Inches								No. & Size of U-Bolts	Ult. Strength Lbs.	Approx. Lbs. per C		Clamp Recom. Ref.
Socket Conn.	Clevis Conn.	Cable Diam.		A	B	C	D	E	R			Net	Pkd.	
		Min.	Max.											
45000	**45010**	.187	.550	5¾	6	3⅞	8	1	2 15/16	2, ½	25000	525	540	44
45040	**45050**	.187	.550	5¾	6	3⅞	8	1	2 15/16	2, ½	30000	525	540	45
45001	**45011**	.30	.68	5¾	6	5½	12½	1 3/16	4¼	4, 9/16	25000	1030	1060	46
45002	**45012**	.30	.84	5¾	6	5½	12½	1 3/16	4¼	4, 9/16	25000	1060	1090	47
45003	**45013**	.76	.96	7⅞	8⅛	7	17 13/16	1 5/16	6⅞	5, ⅝	35000	1642	1682	48
45004	**45014**	.82	1.10	7⅞	8⅛	7	17 13/16	1 5/16	6⅞	5, ⅝	35000	1677	1717	49
45005	**45015**	.96	1.28	7⅞	8⅛	7⅛	21	1 5/16	7¾	6, ⅝	35000	1802	1867	50

CLAMPS

MALLEABLE IRON

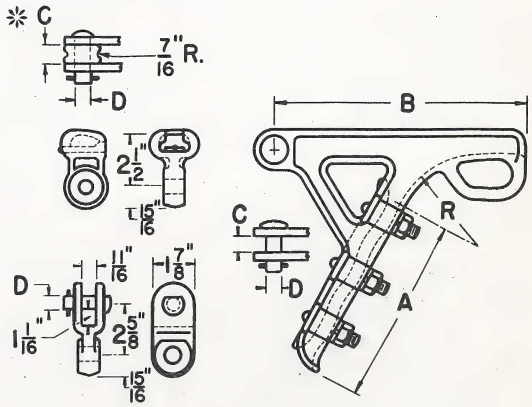


Connectors, bodies and keepers are made of galvanized malleable iron. Cotter bolts are galvanized high strength, heat treated steel.

These clamps are designed for use with copper, Copperweld, ACSR and Amerductor conductors.

Aluminum or copper liners can be furnished at slight extra cost. Specify by adding AL or CL to catalog number. Standard .050″ liners reduce groove diameter by .100″.

For clamp recommendations, see pages 66-73.



Catalog Number	Connector	Dimensions—Inches							No. of U-Bolts	No. of Keeper Pieces	Ult. Strength Lbs.	Approx. Lbs. per C Pkd.	Clamp Recom. Ref.
		Cable Diam.		A	B	C	D	R					
		Min.	Max.										
835 833 834	Socket Clevis None	.200	.460	4⅜	5⅞	¾	⅝	2¾	2	1	14000	540 520 400	51
435 433 437	Socket Clevis None	.200	.550	7½	10	¾	⅝	3¾	3	1	15000	850 850 700	52
440 640 442	Socket Clevis None	.300	.680	9½	11	⅞	⅝	4¾	4	2	20000	1190 1190 1040	53
445 645 447	Socket Clevis None	.475	.840	12	12	1³⁄₃₂	⅝	5½	4	2	25000	1370 1370 1240	54
450 650 452	Socket Clevis None	.500	.960	13	13	1⅛	⅝	6	5	2	25000	1810 1800 1660	55
455 654 *457	Socket Clevis Spool	.710	1.100	16	16	1¼	¾	7½	5	2	27000 27000 30000	2550 2610 2440	56
460 656 *462	Socket Clevis Spool	.750	1.280	20	18	1⁷⁄₁₆	¾	8	6	3	27000 27000 35000	3140 3140 2985	57

* Furnished with metal spool to center shackle on clamp pin.

STRAIN

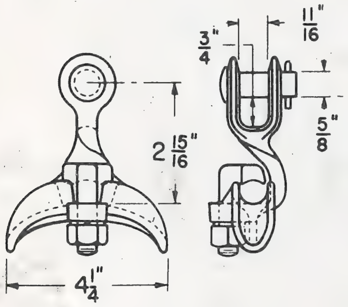
DISTRIBUTION TYPE
FORGED STEEL

These clamps offer an easy, economical way of dead-ending conductors on rural, distribution and medium or light duty transmission lines. All except Nos. 45030 and 45070 are the "Snail Shell" type whose snubbing action develops high holding power without conductor crushing clamping pressure. Each clamp will break, without slip, any conductor for which it is offered.

Factors causing conductor vibration damage are minimized. The light steel parts and short distance between centers of mass and oscillation at the connecting pin, effect a low moment of inertia. This offers little resistance to passage of vibration waves and reduces local conductor bending at clamp mouth to a minimum.

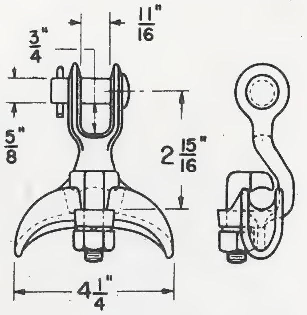
Easy to apply or work hot. Provision is made for use of come-along tackle by the open center. Jumper need not be cut and connectors may be eliminated on many dead-ending positions.

For clamp recommendations, see pages 66-73.



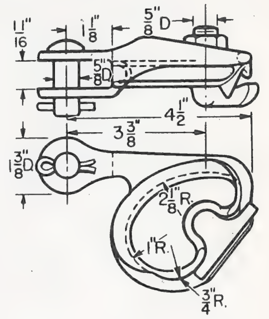
3/4"
11/16"
2 15/16
5/8"
4 1/4"

NO. 42200



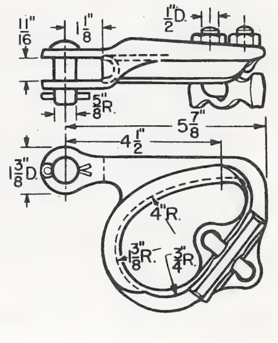
3/4"
11/16
5/8"
2 15/16
4 1/4"

NO. 42300



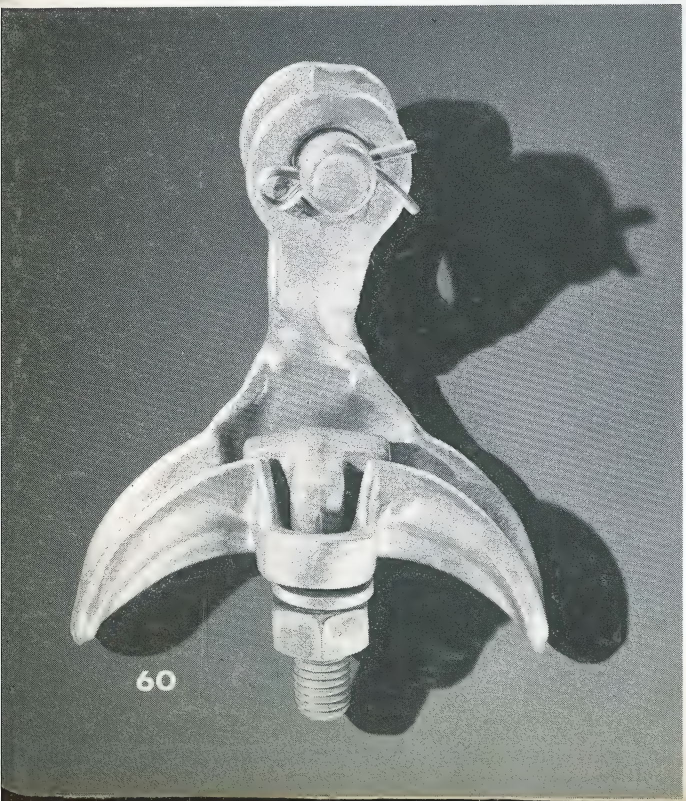
11/16"
1 1/8"
5/8" D
5/8" D
4 1/2"
3 3/8"
1 3/8" D
2 1/8" R.
1" R.
3/4" R.

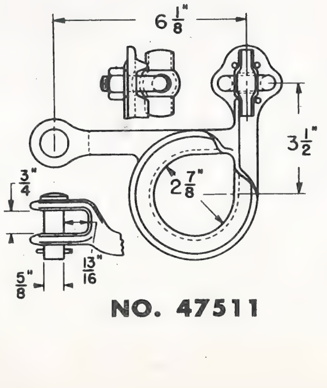
NO. 42122



11/16"
1 1/8"
1/2" D
1"
5/8" R.
5 7/8"
4 1/2"
1 3/8" D
4" R.
1 3/8" R.
3/4" R.

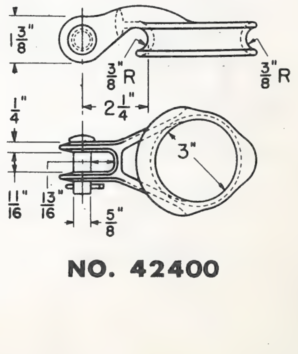
NO. 42124





6 1/8"
3 1/2"
2 7/8"
3/4"
5/8"
13/16

NO. 47511



1 3/8"
3/8" R
3/8" R
1/4"
2 1/4"
3"
11/16"
13/16"
5/8"

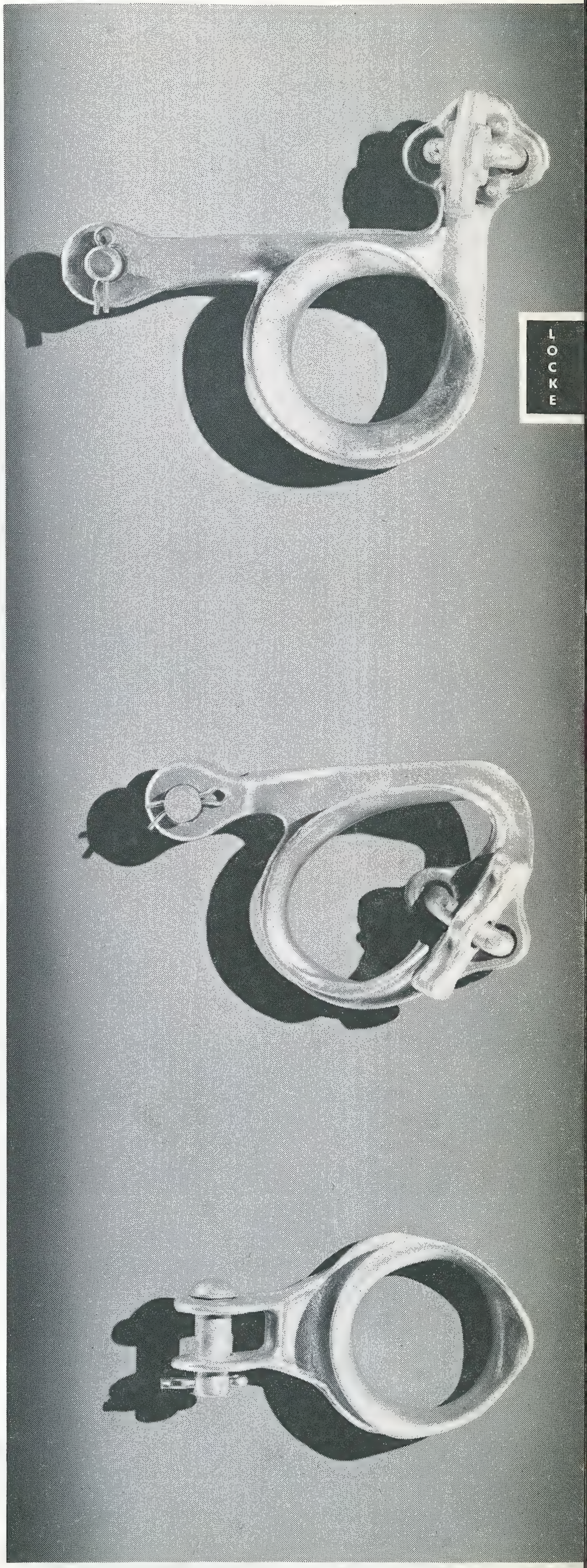
NO. 42400

CLAMPS

Side-opening angle clamps (Nos. 42200 and 42300) are easy to install and work hot. Conductor may be installed or removed without detaching clamp from insulator and without removing T-Bolt Keeper from the Clamp. Nos. 42122, 42124 and 47511 are similarly easy to install and work hot. Conductor may be installed or removed without detaching clamp from insulator.

Side-opening clevis thimble (No. 42400) for angle positions, using tie wires or strain positions, as a dead-end thimble using suitable connectors.

Catalog Number	Cable Diam. Inches		Ult. Strength Lbs.	Lbs. per C Net	Application	Clamp Recom. Ref.
	Min.	Max.				
42200	.120	.600	7000	145	All conductors within range. Side-opening type. For angles up to 120 degrees.	58
42300	.120	.600	7000	145	Same as clamp 42200 above, except clevis is at right angles.	59
42122	.128	.375	8000	150	Ideal for small stranded copper and composite conductors.	60
42124	.160	.500	11000	210	For use on all conductors within its size range.	61
47511	.160	.550	11000	280	Side Opening Type. All conductors within range and strength rating. Conductors can be clamped without threading thru clevis.	62
42400	—	Up to .750	9000	120	Popular for angles and dead ends. For all conductors. Conductors held by tie at each side of thimble.	64

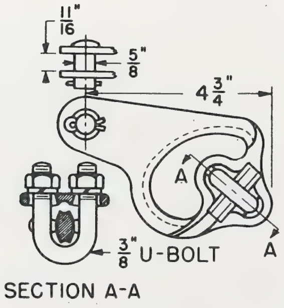


STRAIN

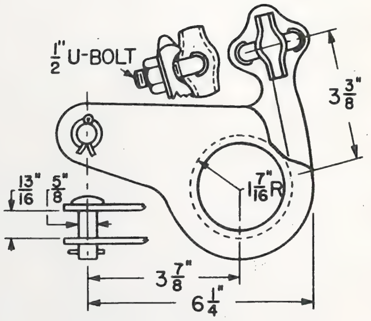
DISTRIBUTION TYPE

MALLEABLE IRON

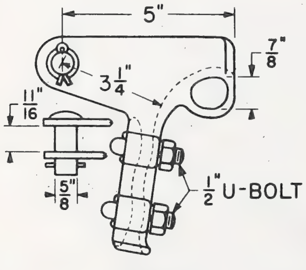
Bodies and keepers are made of galvanized malleable iron. These clamps are designed for use with copper, Copperweld, ACSR and Amerductor conductors.


$\frac{11}{16}$"
$\frac{5}{8}$"
$4\frac{3}{4}$"
A
A
$\frac{3}{8}$" U-BOLT
SECTION A-A

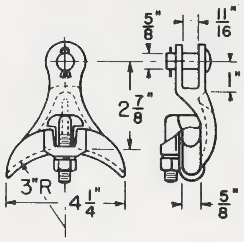
A-1437


$\frac{1}{2}$" U-BOLT
$3\frac{3}{8}$"
$1\frac{7}{16}$"R
$\frac{13}{16}$"
$\frac{5}{8}$"
$3\frac{7}{8}$"
$6\frac{1}{4}$"

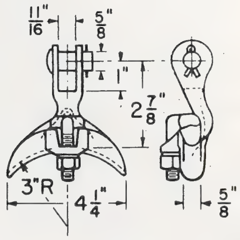
A-1655


5"
$\frac{7}{8}$"
$3\frac{1}{4}$"
$\frac{11}{16}$"
$\frac{5}{8}$"
$\frac{1}{2}$" U-BOLT

A-2050


$\frac{5}{8}$"
$\frac{11}{16}$"
1"
$2\frac{7}{8}$"
3"R
$4\frac{1}{4}$"
$\frac{5}{8}$"

A-2260

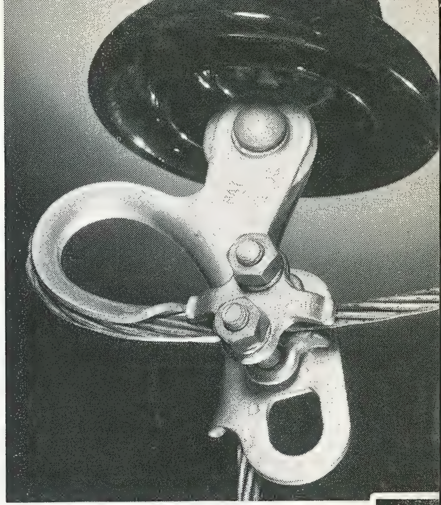

$\frac{11}{16}$"
$\frac{5}{8}$"
1"
$2\frac{7}{8}$"
3"R
$4\frac{1}{4}$"
$\frac{5}{8}$"

A-2270

Catalog Number	Cable Diam. Inches		Ult. Strength Lbs.	Lbs. per C Net	Application	Clamp Recom. Ref.
	Min.	Max.				
*A-1437	.145	.375	7000	135	All conductors within range except A.C.S.R.; particularly good for Copperweld and stranded copper.	65
*A-1655	.160	.550	14000	270	All conductors within range except larger sizes of A.C.S.R., Copperweld and steel.	66
*A-2050	.200	.500	11000	320	All conductors including A.C.S.R. No. 4 to 1/0.	67
A-2260	.200	.600	7000	145	All conductors within range. Side-opening type. Used for angles up to 120 degrees.	68
A-2270	.200	.600	7000	145	Same as clamp A-2260 above, except clevis is at right angles.	69

* If socket connectors are required, please specify on order.

CLAMPS



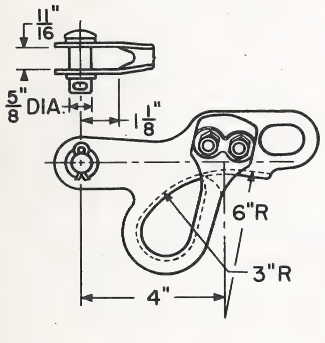
DISTRIBUTION TYPE
PRESSED STEEL

One-piece body of galvanized heavy gauge Chrome-Nickel-Copper-Manganese alloy steel gives high ultimate strength, yield point and endurance limit. Highly resistant to shock and fatigue. Corrosion resistance 5 to 6 times that of carbon steel under all atmospheric conditions. Metal around connecting pin holes is extruded to increase the bearing surface on the pin. Only one bolt need be removed and only one wrench used in application, except on No. 42116 which has a reversible clamping keeper. If socket connector is required, please specify on order.

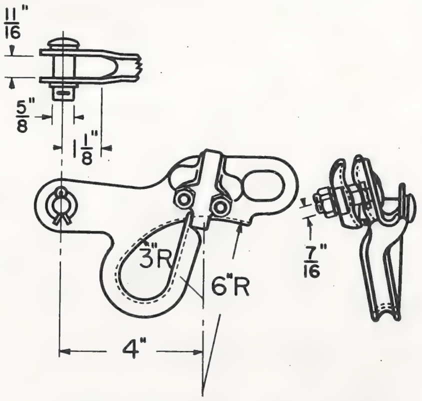
Easy to apply and work hot. Provision is made for use of come-along tackle by the loop. Jumper need not be cut and connectors may be eliminated on many dead-ending positions.

For further information, note description on top of page 60, which also applies to these clamps.

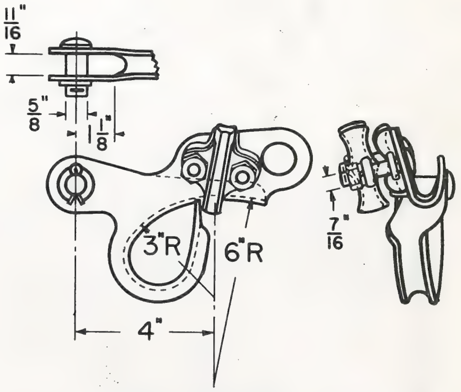
For clamp recommendations, see pages 66-73.



NO. 42106



NOS. 42107 and 42115



NO. 42116

Catalog Number	Cable Diam. Inches		Ult. Strength Lbs.	Lbs. per C Net	Application	Clamp Recom. Ref.
	Min.	Max.				
42106	.160	.366	7000	150	All conductors within range except A.C.S.R. and all aluminum. Not recommended for high strength steel.	70
42107	.158	.398	9000	200	For A.C.S.R. and all aluminum only. Aluminum lined. No armor tape required. Exceptional holding power.	
42115	.187	.437	9000	200	Same as 42107 except without liners. For all conductors except A.C.S.R. and all aluminum but including A.C.S.R. and all aluminum with tape.	71
42116	.160	.550	10000	232	All conductors within range. Requires use of tape for A.C.S.R. and all aluminum. Popularly used for urban and suburban construction.	72

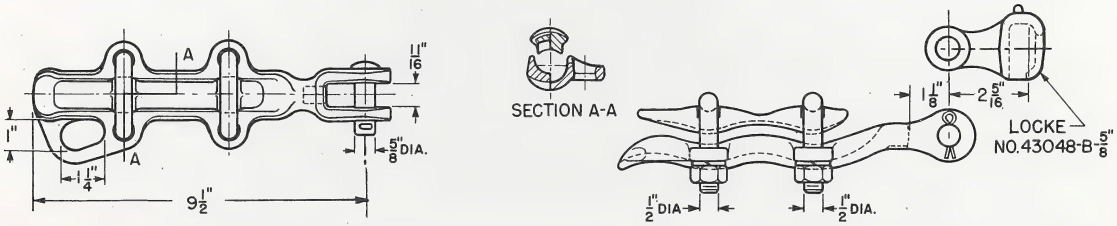
STRAIGHT LINE
FORGED STEEL

For use on distribution lines or strain buses in substations where spans are short or moderately long and conductor tensions relatively low. Compact and easily hooded for hot line maintenance. Come-along eyes are of ample size and strength. Holding power varies with relation of conductor diameter to clamp bore. Maximum holding power with the larger accommodated conductors is 5,000 lbs., when U-Bolt nuts are uniformly tightened with a torque of 60-70 ft.-lbs.

Steel clamps are suitable for use with all conductor types within clamp range, when fitted with appropriate liners. Aluminum or copper liners can be furnished at slight extra cost. Specify by adding AL or CL to catalog number. Standard .050″ liners reduce groove diameter by .100″.

For clamp recommendations, see pages 66-73.

Clamp bodies, keepers and socket eyes are galvanized drop-forged 1038 steel. Cotter bolt is galvanized high-strength, heat treated steel. Cotter key is copper alloy.



Catalog Number	Type of Connector	Type of Liner	Cable Diam.—Inches		Ultimate Strength Lbs.	Approx. Lbs. per C		Clamp Recom. Ref.
			Min.	Max.		Net	Pkd.	
45100	None	None	.460	.900	15000	360	364	73
45148	Socket	None	.460	.900	15000	440	444	74

ALUMINUM ALLOY

Design, application and holding power of these clamps are the same as described for forged steel straight line clamps near the top of this page.

They are suitable for ACSR and all-aluminum conductors within the diameter range of the clamp. Liners are not furnished. For clamp recommendations, see pages 66-73.

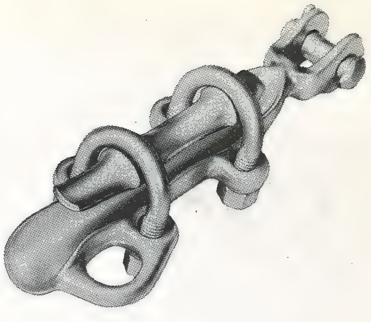
Clamp bodies and keepers are drop forged aluminum alloy, heat treated. Socket eye is galvanized, drop-forged 1038 steel. Cotter bolt is galvanized, high strength, heat treated steel. Cotter key is copper alloy.

Catalog Number	Type of Connector	Cable Diam.—Inches		Ultimate Strength Lbs.	Approx. Lbs. per C		Clamp Recom. Ref.
		Min.	Max.		Net	Pkd.	
45400	None	.460	.910	12000	225	229	75
45448	Socket	.460	.910	12000	310	314	76

For clamps with high holding power for dead-ending long span high voltage transmission conductors see pages 57–59.

CLAMPS

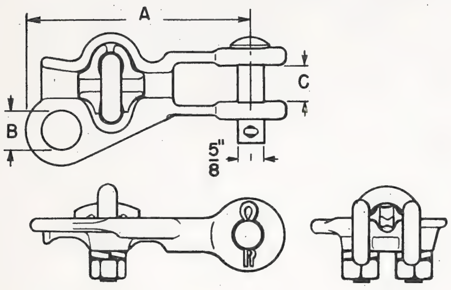
STRAIGHT LINE
MALLEABLE IRON


Forged Steel
Straight Line
Strain Clamp

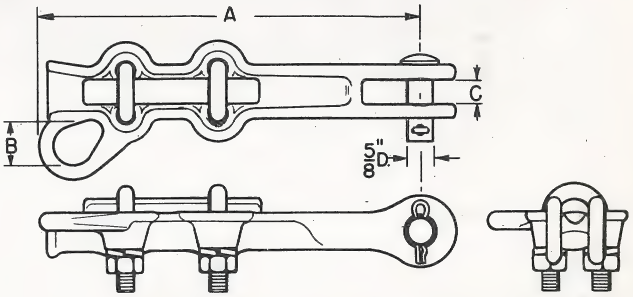
For dead-ending distribution primary and secondary copper aluminum or ACSR conductor, where inexpensive straight line dead end clamps with moderate holding power are needed. They are easily and effectively hooded for hot line maintenance work and are provided with suitable come-along eyes to assist in installation and sagging of conductors. Their holding power depends on the kind of conductor and its size, relative to the clamp bore. The approximate slip strengths listed indicate typical results when the clamp bolts are uniformly tightened with a torque of 40-50 ft. lbs.

Aluminum or copper liners can be furnished at slight extra cost. Specify by adding AL or CL to catalog number. Standard .050″ liners reduce groove diameter by .100″. For clamp recommendations, see pages 66-73.

Clamp bodies and keepers are galvanized, high grade malleable iron. U-Bolts, nuts, washers and cotter bolts are galvanized steel. Spring cotters are copper alloy, humped type, self locking to simplify hot line work.



NO. A-1638



ALL OTHERS

Catalog Number	Connector	Dimensions—Inches					Ult. Stgth. Lb.	Approx. Slip Strength Lbs.	Approx. Lbs. per C, Pkd.	Clamp Recom. Ref.
		Cable Diam.		A	B	C				
		Min.	Max.							
A-1638*	None	.16	.38	4 11/16	3/4	3/4	7000	2500	200	77
A-30621 **A-30631** **A-30641**	None Socket Clevis	.30	.62	8 3/8	1	3/4	10000	5000	310 440 435	78
A-45901 **A-45911** **A-45921**	None Socket Clevis	.45	.90	9 9/16	1	3/4	12000	5000	425 555 550	79
A-62125 **A-62126** **A-62127**	None Socket Clevis	.62	1.25	11 1/2	1	3/4	15000	5000	615 745 740	80
A-80156 **A-80157** **A-80158**	None Socket Clevis	.80	1.56	13 1/8	1	13/16	17000	6000	740 870 865	81

* Furnished with reversible keeper to accommodate wide range of conductors.

RECOMMENDED SUSPENSION AND STRAIN CLAMPS

The reference numbers shown under SUSPENSION CLAMPS and STRAIN CLAMPS refer to numbers in the last column of the respective clamp data table on those pages where the particular clamps are listed.

Size AWG or CM	Copper Equiv. AWG or CM	Stranding (Wires)		Diameter—Inches				Ult. Strength Lbs.	Lbs. per 1000 Ft.	Strain Clamps—Ref. No.		
		Alum.	Steel	Over Bare Cable	Over Conv. Rods	Over Pref. Rods*				Forged Steel	Mall. Iron	Alum. Alloy
						Alum.	Steel†					
6	8	6x.0661	1x.0661	.198	.434			1170	36.2	44, 58–64	77	38
5	7	6x.0743	1x.0743	.223	.491			1460	45.7	44, 58–64	51, 77	38
4	6	6x.0834	1x.0834	.250	.548	.542	.438	1830	57.6	44, 58–64	51, 77	38
4	6	7x.0772	1x.1029	.257	.555	.549	.445	2288	67.4	44, 58–64	51, 77	38
3	5	6x.0937	1x.0937	.281	.521			2250	72.7	44, 58–64	51, 77	38
2	4	6x.1052	1x.1052	.316	.586	.608	.504	2790	91.6	44, 58–64	51, 77, 78	38
2	4	7x.0974	1x.1299	.325	.595	.617	.513	3525	107.2	44, 58–64	51, 77, 78	38
1	3	6x.1182	1x.1182	.355	.657	.647	.543	3480	115.5	44, 58–64	51, 77, 78	38
1/0	2	6x.1327	1x.1327	.398	.744	.732	.616	4280	145.6	44, 58, 59, 61–64	51, 78	38
2/0	1	6x.1490	1x.1490	.447	.835	.781	.665	5345	183.7	46, 58, 59, 61–64	51, 78	38
3/0	1/0	6x.1672	1x.1672	.502	.938	.836	.774	6675	231.6	46, 58, 59, 64, 73, 74	52, 78, 79	38, 75, 76
4/0	2/0	6x.1878	1x.1878	.563	1.051	.927	.835	8420	292.1	47, 58, 59, 64, 73, 74	53, 78, 79	39, 75, 76
266800	3/0	6x.2109	7x.0703	.633	1.179	.997	.929	9645	341.3	47, 64, 73, 74	53, 79, 80	39, 75, 76
266800	3/0	26x.1013	7x.0788	.642	1.188	1.006	.938	11250	365.6	47, 64, 73, 74	53, 79, 80	39, 75, 76
300000	188700	26x.1074	7x.0835	.680	1.258	1.088	1.004	12650	411.0	47, 64, 73, 74	53, 79, 80	40, 75, 76
300000	188700	30x.1000	7x.1000	.700	1.294	1.108	1.024	15430	469.1	47, 64, 73, 74	54, 79, 80	40, 75, 76
336400	4/0	26x.1138	7x.0885	.721	1.349	1.129	1.045	14050	462.4	48, 64, 73, 74	54, 79, 80	40, 75, 76
336400	4/0	30x.1059	7x.1059	.741	1.369	1.149	1.065	17040	526.1	48, 64, 73, 74	54, 79, 80	40, 75, 76
397500	250000	26x.1236	7x.0961	.783	1.447	1.283		16190	546.4	48, 73, 74	54, 79, 80	40, 75, 76
397500	250000	30x.1151	7x.1151	.806	1.490	1.306		19980	621.6	48, 73, 74	54, 79–81	40, 75, 76
477000	300000	26x.1355	7x.1054	.858	1.602	1.358		19430	655.7	49, 73, 74	55, 79–81	41, 75, 76
477000	300000	30x.1261	7x.1261	.883	1.649	1.383		23300	745.9	49, 73, 74	55, 79–81	41, 75, 76
500000	314500	30x.1291	7x.1291	.904	1.670	1.404		24400	781.9	49, 74	55, 80, 81	41, 75, 76
556500	350000	26x.1463	7x.1138	.927	1.715	1.427		22400	765.	49, 74	55, 80, 81	42
556500	350000	30x.1362	7x.1362	.953	1.763	1.453		27200	870.	49	55, 80, 81	42
605000	380500	54x.1059	7x·1059	.953	1.763	1.453		22500	779.	49	55, 80, 81	42
605000	380500	26x.1525	7x.1186	.966	1.798	1.466		24100	832.	49	56, 80, 81	42
605000	380500	30x.1420	19x.0852	.994	1.850	1.614		30000	938.	50	56, 80, 81	42
636000	400000	54x.1085	7x.1085	.977	1.809	1.477		23600	818.	50	56, 80, 81	42
636000	400000	26x.1564	7x.1216	.990	1.846	1.610		25000	874.	50	56, 80, 81	42
636000	400000	30x.1456	19x.0874	1.019	1.901	1.639		31500	986.	50	56, 80, 81	42
666600	419000	54x.1111	7x.1111	1.000	1.856	1.620		24500	858.	50	56, 80, 81	42
715500	450000	54x.1151	7x.1151	1.036	1.918	1.656		26300	922.	50	56, 80, 81	42
715500	450000	26x.1659	7x.1290	1.051	1.959	1.671		28100	987.	50	56, 80, 81	42
715500	450000	30x.1544	19x.0926	1.081	2.013	1.701		34600	1111.	50	56, 80, 81	43
795500	500000	54x.1214	7x.1214	1.093	2.025	1.713		28500	1026.	50	56, 80, 81	43
795500	500000	26x.1749	7x.1360	1.108	2.040	1.728		31200	1098.	50	57, 80, 81	43
795500	500000	30x.1628	19x.0977	1.140	2.128	1.760		38400	1237.	50	57, 80, 81	43
874500	550000	54x.1273	7x.1273	1.146	2.134			31400	1125.	50	57, 80, 81	43
900000	566000	54x.1291	7x.1291	1.162	2.150			32300	1158.	50	57, 80, 81	43
954000	600000	54x.1329	7x.1329	1.196	2.212			34200	1227.		57, 80, 81	43
1033500	650000	54x.1384	7x.1384	1.246	2.322			37100	1330.		57, 80, 81	43
1113000	700000	54x.1436	19x.0862	1.293				40200	1429.		81	
1192500	750000	54x.1486	19x.0892	1.338				43100	1534.		81	
1272000	800000	54x.1535	19x.0921	1.382				44800	1636.		81	
1351500	850000	54x.1582	19x.0949	1.424				47600	1738.		81	
1431000	900000	54x.1628	19x.0977	1.465				50400	1840.		81	
1510500	950000	54x.1673	19x.1004	1.506				53200	1943.		81	
1590000	1000000	54x.1716	19x.1030	1.545				56000	2045.		81	

Note: Standard .050″ liners reduce clamp groove diameter by .100″.

†To be used only if recommended by cable manufacturer. (Not to be used over 200 amps.)

FOR ACSR CONDUCTORS

Example: To determine the Locke forged steel suspension clamp for a specific conductor over bare cable, select the conductor size or AWG or CM gauge in the first column, move horizontally to the desired column and note reference number. The clamp needed may be found on page 55, opposite the reference number in the column headed: "Clamp Recom. Ref."

Suspension Clamps—Reference Number												Size AWG or CM
Over Bare Cable			Over Conventional Armor Rods			Over Al. Preformed Armor Rods*			Over Steel Preformed Armor Rods*			
Fgd. Steel	Mall. Iron	Al. Alloy	Fgd. Steel	Mall. Iron	Al. Alloy	Fgd. Steel	Mall. Iron	Al. Alloy	Fgd. Steel	Mall. Iron	Al. Alloy	
10	25		10	25								6
10	25		11	26								5
10	25		11	26		11				25		4
10	25		11	26		11	26		10	25		4
10	25		11	26			26		10			3
10	25		11	26		13	27		11	26		2
10	25		11	26		13	27		11	26		2
11	26		13	27		13	27		11	26		1
11	26		14	28		14	28		13	27		1/0
11	26		15	29	1	14	28		13	27		2/0
13	27		15	29	1	15	29	1	14	28		3/0
13	27		16	30	2	15	29	1	15	29		4/0
14	28		17	31	3	15	29	1	15	29		266800
14	28		17	31	3	16	29	1	15	29		266800
14	28		17	31	3	16	30	2	16	30		300000
15	29		18	32	4	16	30	2	16	30		300000
15	29		18	32	4	16	30	2	16	30	NOT RECOMMENDED	336400
15	29		18	32	4	16	30	2	16	30		336400
15	29		19	33	4	18	32	4				397500
15	29	1	20	34	5	18	32	4				397500
15	29	1	21	34	5	18	32	4				477000
16	30	1	21	35	6	19	33	4				477000
16	30	1	21	35	6	19	33	4				500000
16	30	1	21	35	6	19	33	4				556500
16	30	1	21	35	6	20	33	4				556500
16	30	1	21	35	6	20	33	4				605000
16	30	1	21	35	6	20	34	5				605000
16	30	2	22	36	7	21	35	6				605000
16	30	2	22	36	7	20	34	5				636000
16	30	2	22	36	7	21	35	6				636000
16	32	2	22	36	7	21	35	6				636000
16	30	2	22	36	7	21	35	6				666600
17	32	2	22	36	7	21	35	6				715500
17	32	2	22	36	7	21	35	6				715500
17	32	2	23	37	8	21	35	6				715500
17	32	3	23	37	8	21	35	6				795500
17	32	3	23	37	8	21	35	6				795500
18	32	3	23	37	8	21	35	6				795500
18	32	3	23	37	8							874500
18	32	3	23	37	8							900000
18	32	3	23	37	8							954000
19	33	4	24		9							1033500
19	33	4										1113000
20	34	4										1192500
20	34	4										1272000
20	34	5										1351500
21	35	5										1431000
21	35	5										1510500
21	35	5										1590000

*Clamps recommended for diameter over preformed rods as shown. Due to some changes in preformed rod sizes, diameter should be verified on basis of rod size used, before ordering clamps.

RECOMMENDED SUSPENSION AND STRAIN CLAMPS FOR

The reference numbers shown under SUSPENSION CLAMPS and STRAIN CLAMPS refer to numbers in the last column of the respective clamp data table on those pages where the particular clamps are listed.

Size AWG or CM	Copper Equiv. AWG or CM	Stranding (Wires)		Diameter—Inches				Ult. Strength Lbs.	Lbs. per 1000 Ft.	Strain Clamps—Ref. No.		
		Alum.	Steel	Over Bare Cable	Over Conv. Rods	Over Pref. Rods* Alum.	Over Pref. Rods* Steel†			Forged Steel	Mall. Iron	Alum. Alloy
80000	50310	8x.1000	1x.1670	.367	.687	.655	.555	5200	149.8	58–64	51, 77, 78	38
101800	64160	12x.0921	7x.0921	.461	.861	.795	.733	9860	253.6	46, 58–64, 73, 74	52, 78, 79	38
110800	69700	12x.0961	7x.0961	.481	.893	.815	.753	10730	276.0	46, 58, 59, 61–64, 73, 74	52, 78, 79	38
134600	84600	12x.1059	7x.1059	.530	.990	.864	.802	12920	335.2	46, 58, 59, 62, 64, 73, 74	52, 78, 79	38
159000	100000	12x.1151	7x.1151	.576	1.078	.940	.848	15200	396.0	47, 58, 59, 64, 73, 74	53, 78, 79	39
176900	111200	12x.1214	7x.1214	.607	1.123	.971	.879	16440	440.6	47, 64, 73, 74	53, 78, 79	39
190800	120000	12x.1261	7x.1261	.631	1.177	.995	.903	17730	475.2	47, 64, 73, 74	53, 79, 80	39
203200	127800	16x.1127	19x.0977	.714	1.324	1.122	1.038	27500	674.9	64	54, 79, 80	40
211300	132900	12x.1327	7x.1327	.663	1.241	1.071	.987	19640	526.3	47, 71, 73, 74	53, 79, 80	39

RECOMMENDED SUSPENSION AND STRAIN CLAMPS FOR

Size	Stranding	Diameter—Inches		Breaking Load—Lbs.				Lbs. per 1000 Ft.	Suspension Clamps—Ref. No.			
		Over Bare Cable	Over Steel Preformed Rods*	Standard	Siemens-Martin	High Strength	Extra High Strength		Over Bare Cable Forged Steel	Over Bare Cable Mall. Iron	Over Steel Pref. Rods* Forged Steel	Over Steel Pref. Rods* Mall. Iron
5/32	7	.157	.345	870				51.3	10		10	25
3/16	7	.187	.375	1150	1900	2850	3990	72.9	10		10	25
1/4	7	.240	.428	1900	3150	4750	6650	121	10	25	10	25
9/32	7	.279	.467		4250			164	10	25	11	26
5/16	7	.312	.500	3200	5350	8000	11200	205	10	25	11	26
3/8	7	.362	.580	4250	6950	10800	15400	296	10	25	13	27
7/16	7	.435	.707	5700	9350	14500	20800	399	10	25	14	28
1/2	7	.495	.791	7400	12100	18800	26900	517	11	26	15	29
5/8	19	.625		11000	18100	28100	40200	796	13	27		
3/4	19	.750		16000	26200	40800	58300	1151	14	28		
7/8	19	.875		21900	35900	55800	97700	1581	15	29		
1	19	1.000		28700	47000	73200	104500	2073	16	30		

Note: Standard .050" liners reduce clamp groove diameter by .100".
†To be used only if recommended by cable manufacturer. (Not to be used over 200 amps.)

SPECIAL HIGH-STRENGTH ACSR CONDUCTORS

Example: To determine the Locke forged steel suspension clamp for a specific conductor over bare cable, select the conductor size or AWG or CM gauge in the first column, move horizontally to the desired column and note reference number. The clamp needed may be found on page 55, opposite the reference number in the column headed: "Clamp Recom. Ref."

Suspension Clamps—Reference Number												Size AWG or CM
Over Bare Cable			Over Conventional Armor Rods			Over Al. Preformed Armor Rods*			Over Steel Preformed Armor Rods*			
Fgd. Steel	Mall. Iron	Al. Alloy	Fgd. Steel	Mall. Iron	Al. Alloy	Fgd. Steel	Mall. Iron	Al. Alloy	Fgd. Steel	Mall. Iron	Al. Alloy	
11	26		13	27		13	27		11	26	NOT RECOMMENDED	80000
11	26		15	29	1	14	28		14	28		101800
13	27		15	29	1	14	28		14	28		110800
13	27	1	15	29	1	15	29	1	14	28		134600
13	27	1	16	30	2	15	29	1	15	29		159000
14	28	1	16	30	2	15	29	1	15	29		176900
14	28	1, 2	17	31	3	15	29	1	15	29		190800
15	29	1, 2	18	32	4	16	30	2	16	30		203200
14	28	1, 2	17	31	3	16	30	2	15	29		211300

GALVANIZED STEEL CONDUCTORS

Strain Clamps—Reference Number												Size
Standard Cable without Fitting**			Siemens-Martin Cable without Fitting**			High Strength Cable without Fitting**			Extra High Strength Cable without Fitting**			
Fgd. Steel	Pressed St.	Mall. Iron	Fgd. Steel	Pressed St.	Mall. Iron	Fgd. Steel	Pressed St.	Mall. Iron	Fgd. Steel	Pressed St.	Mall. Iron	
60		65										5/32
60	72	65	60	72	65	60	72	65	60	72	65	3/16
60	72	65	60	72	65	60	72	65	60	72	65	1/4
			60	72	65							9/32
60	72	65	60	72	65	64	72	67			52	5/16
60	72	65	61	72	67	44‡		52	44‡			3/8
61	72	67	64	72	67	44‡		52	44‡			7/16
61	72	67	44‡		52	44‡			45‡			1/2
46‡		53	46‡		53							5/8
47‡		54										3/4
48‡		55										7/8
49‡												1

‡ Refers to clamps offered with socket connectors.

---

*Clamps recommended for diameter over preformed rods as shown. Due to some changes in preformed rod sizes, diameter should be verified on basis of rod size used, before ordering clamps.

**If socket or clevis connectors are desired, please specify on Locke Cat. Nos. 42106, 42107, 42115, 42116, A-1437, A-1655 and A-2050.

RECOMMENDED SUSPENSION AND STRAIN CLAMPS FOR

The reference numbers shown under SUSPENSION CLAMPS and STRAIN CLAMPS refer to numbers in the last column of the respective clamp data table on those pages where the particular clamps are listed.

Size AWG or CM	Stranding	Diameter—Inches			Breaking Strength Lbs. Hard Drawn	Maximum Resistance Ohms/1000 Ft. Hard Drawn	Lbs. per 1000 Ft.	Current Rating—Amps.	
		Over Bare Cable	Over Preformed Rods*					Indoor Service	Outdoor Service
			Bronze	Steel†					
6	7 Wire	.184	.388	.372	1228	.4191	81.0		
6	3 Wire	.201	.405	.389	1204	.4149	80.26		
5	7 Wire	.206	.410	.394	1542	.3324	102.2		
5	3 Wire	.226	.430	.414	1504	.3291	101.2		
4	7 Wire	.232	.436	.420	1938	.2636	128.9		
4	3 Wire	.254	.458	.442	1879	.2610	127.6		
3	7 Wire	.260	.464	.448	2433	.2090	162.5		
3	3 Wire	.285	.489	.475	2359	.2070	160.9		
2	7 Wire	.292	.496	.480	3045	.1658	204.9		
2	3 Wire	.320	.576	.508	2913	.1641	202.9		
1	7 Wire	.328	.584	.516	3804	.1315	258.4		
1	3 Wire	.360	.616	.632	3620	.1302	255.9		
1/0	7 Wire	.368	.624	.640	4750	.1043	325.7	175	245
2/0	7 Wire	.414	.738	.686	5927	.08765	410.9	205	285
3/0	7 Wire	.464	.788	.736	7366	.06556	518.1		
3/0	12 Wire	.492	.816	.764	7556	.06556	518.1		
4/0	7 Wire	.522	.846	.794	9154	.05199	653.3	280	385
4/0	19 Wire	.528	.852	.800	9617	.05199	653.3	280	385
4/0	12 Wire	.552	.876	.824	9483	.05199	653.3	280	385
250000	19 Wire	.574	.938	.898	11360	.04400	771.9	320	435
250000	12 Wire	.600	.964	.924	11130	.04400	771.9	320	435
300000	19 Wire	.629	.993	.953	13510	.03667	926.3		
300000	12 Wire	.657	1.083	.981	13170	.03667	926.3		
350000	19 Wire	.679	1.043	1.003	15590	.03143	1081		
350000	12 Wire	.710	1.074	1.034	15140	.03143	1081		
400000	19 Wire	.726	1.090	1.050	17560	.02750	1235	435	580
450000	19 Wire	.770	1.134	1.094	19750	.02445	1389		
450000	37 Wire	.772	1.136	1.096	20450	.02445	1389		
500000	19 Wire	.811	1.175	1.135	21950	.02200	1544	570	670
500000	37 Wire	.813	1.177	1.137	22510	.02200	1544	510	670
550000	37 Wire	.853			24760	.02000	1698		
600000	37 Wire	.891			27020	.01824	1853	590	755
650000	61 Wire	.929			29770		2007		
700000	37 Wire	.963			31170	.01572	2161		
700000	61 Wire	.964			31820	.01572	2161		
750000	37 Wire	.997			33400	.01467	2316	675	865
750000	61 Wire	.998			34090	.01467	2316	675	865
800000	37 Wire	1.029			35120	.01375	2470		
800000	61 Wire	1.031			36020	.01375	2470		
850000	61 Wire	1.062			38270		2624		
900000	37 Wire	1.092			39510	.01222	2779		
900000	61 Wire	1.094			40520	.01222	2779		
950000	61 Wire	1.123			42780		2933		
1000000	61 Wire	1.152			45030	.01100	3088		

Note: Standard .050″ liners reduce clamp groove diameter by .100″.
†To be used only if recommended by cable manufacturer. (Not to be used over 200 amps.)

STRANDED AND SOLID COPPER CONDUCTORS

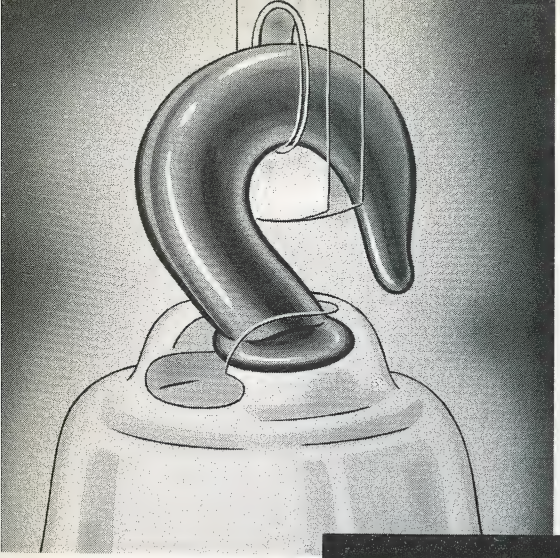
Example: To determine the Locke forged steel suspension clamp for a specific conductor over bare cable, select the conductor size or AWG or CM gauge in the first column, move horizontally to the desired column and note reference number. The clamp needed may be found on page 55, opposite the reference number in the column headed: "Clamp Recom. Ref."

Strain Clamps—Ref. No.		Suspension Clamps—Reference Number						Size AWG or CM
Forged Steel	Malleable Iron	Over Bare Cable		Over Bronze or Pref. Armor Rods*		Over Steel Pref. Armor Rods*		
		Fgd. Steel	Mall. Iron	Fgd. Steel	Mall. Iron	Fgd. Steel	Mall. Iron	
58–62, 64, 70, 72	65, 66, 77	10		10	25	10	25	6
58–64, 70–72	65, 66, 77	10	25	10	25	10	25	6
58–64, 70–72	65, 66, 77	10	25	10	25	10	25	5
58–64, 70–72	65, 66, 77	10	25	10	25	10	25	5
58–64, 70–72	65, 66, 77	10	25	10	25	10	25	4
58–64, 70–72	65, 66, 77	10	25	11	26	10	25	4
58–64, 70–72	65, 66, 77	10	25	11	26	11	26	3
58–64, 70–72	65, 66, 77	10	25	11	26	11	26	3
58–64, 70–72	65, 66, 77	10	25	11	26	11	26	2
58–64, 70–72	65, 66, 77, 78	10	25	13	27	11	26	2
58–64, 70–72	65, 66, 77, 78	10	25	11	26	11	26	1
58–64, 70–72	65, 66, 77, 78	10	25	13	27	13	27	1
58–64, 71, 72	65, 66, 77, 78	10	25	13	27	13	27	1/0
58, 59, 61–64, 71, 72	52, 66, 67, 78	10	25	14	28	14	28	2/0
44, 58, 59, 61–64, 72–74	52, 66, 67, 78, 79	11	26	14	28	14	28	3/0
44, 58, 59, 61–64, 72–74	52, 66, 67, 78, 79	11	26	15	29	14	28	3/0
44, 58, 59, 62, 64, 72–74	52, 78, 79	11	26	15	29	15	29	4/0
44, 58, 59, 62, 64, 72–74	52, 78, 79	11	26	15	29	15	29	4/0
46, 58, 59, 64, 73, 74	53, 78, 79	11	26	15	29	15	29	4/0
46, 58, 59, 64, 73, 74	53, 78, 79	11	26	15	29	15	29	250000
46, 64, 73, 74	53, 78, 79	13	27	15	29	15	29	250000
46, 64, 73, 74	53, 79, 80	13	27	16	30	15	29	300000
46, 64, 73, 74	53, 79, 80	13	27	16	30	16	30	300000
47, 64, 73, 74	54, 79, 80	13	27	16	30	16	30	350000
47, 64, 73, 74	54, 79, 80	14	28	16	30	16	30	350000
47, 64, 73, 74	54, 79, 80	14	28	16	30	16	30	400000
47, 73, 74	54, 79, 80	14	28	17	32	16	30	450000
47, 73, 74	54, 79, 80	14	28	17	32	16	30	450000
47, 73, 74	54, 79–81	15	29	17	32	17	32	500000
47, 73, 74	54, 79–81	15	29	17	32	17	32	500000
48, 73, 74	55, 79–81	15	29			17	32	550000
48, 73, 74	55, 79–81	15	29			17	32	600000
48	56, 80, 81	15	29			18	32	650000
49	56, 80, 81	15	29			18	32	700000
49	56, 80, 81	15	29			18	32	700000
49	56, 80, 81	16	30			19	33	750000
49	56, 80, 81	16	30			19	33	750000
49	56, 80, 81	16	30			19	33	800000
49	56, 80, 81	16	30			19	33	800000
49	56, 80, 81	16	30			20	34	850000
50	57, 80, 81	16	30			20	34	900000
50	57, 80, 81	16	30			20	34	900000
50	57, 80, 81	17	32			20	34	950000
50	57, 80, 81	17	32			20	34	1000000

*Clamps recommended for diameter over preformed rods as shown. Due to some changes in preformed rod sizes, diameter should be verified on basis of rod size used, before ordering clamps.

Pages 72-73 intentionally left out

SUSPENSION



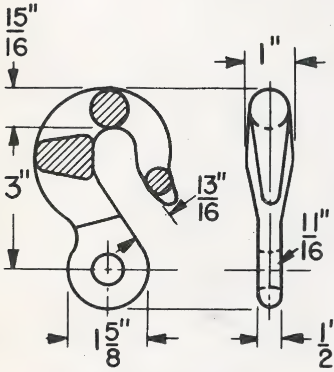
HOOK
FORGED STEEL

Locke suspension fittings provide the construction and design engineer with standard, stock items for most requirements. Use of these fittings assures you of high quality, uniform materials, available for quick delivery.

All forged steel fittings are made of high grade steel, especially selected for its corrosion resisting qualities. Malleable iron fittings are scientifically treated to insure against brittleness after galvanizing.

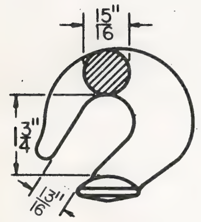
Double hot-dip galvanizing assures a smooth, uniform, corrosion resistant zinc coating.

Cotter keys are made of copper alloy. While ductile, these keys will not distort or corrode in service.



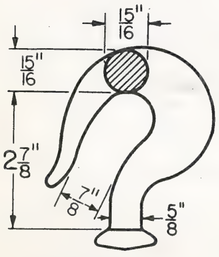
NO. 43000

EYE HOOK
Used for attaching clevis type suspension insulators to a structure.

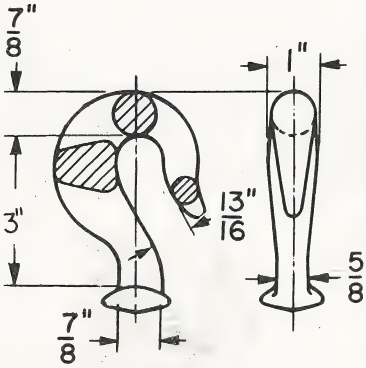


NO. 43001

BALL HOOK
Used for attaching ball and socket type suspension insulators to a structure. Nos. 43001 and 43003 have flattened shanks to prevent turning in socket.



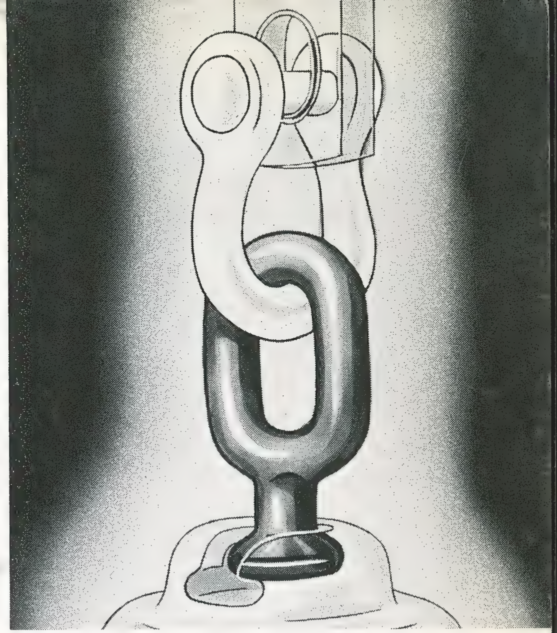
NO. 43002



NO. 43003

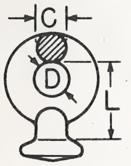
Catalog No. Std. Strength. For Heat-Treated, add HT	Ultimate Strength—Lb.		Approx. Lbs. per C Pkd.
	Standard	Heat-Treated HT	
43000	17,000	25,000	128
43001	18,000	25,000	116
43002	18,000	25,000	147
43003	18,000	25,000	135

FITTINGS

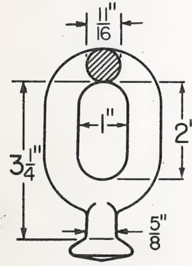


BALL EYE
FORGED STEEL

Used for attaching suspension insulators to a structure. Also used to connect ball and socket to clevis fittings.



NOS. 43010
43012
43013

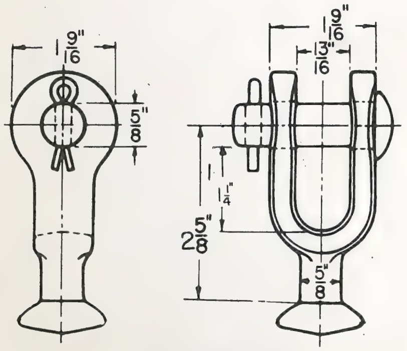


NO. 43014

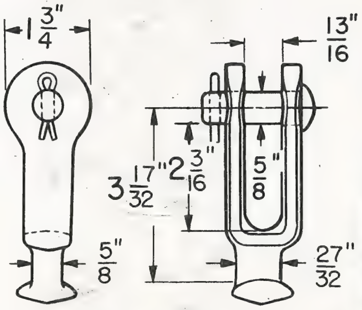
Catalog No. Std. Strength. For Heat-Treated, Add HT	Dimensions—Inches			Ultimate Strength-Lbs.		Approx. Lbs. per C Pkd.
	C	D	L	Standard	Heat-Treated HT	
43010	9/16	11/16	1 19/32	18,000	25,000	50
43012	9/16	1 1/16	2 1/32	18,000	25,000	65
43013	13/16	13/16	2 3/32	18,000	25,000	90
43014	See Drawing			20,000	35,000	100

BALL CLEVIS
FORGED STEEL

Used for attaching suspension insulators to a structure. Also used to connect ball and socket to eye fittings. No. 43056 has flattened shank to prevent turning in socket.

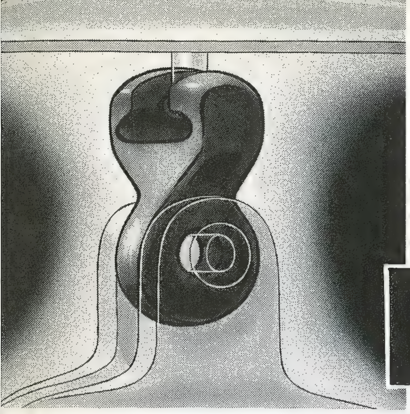


NO. 43055



NO. 43056

Catalog No. Std. Strength. For Heat-Treated, Add HT	Ultimate Strength-Lbs.		Approx. Lbs. per C Pkd.
	Standard	Heat-Treated HT	
43055	18,000	25,000	95
43056	20,000	30000	135



SUSPENSION AND

SOCKET EYE

Used for combining ball and socket with clevis type insulators. Also used to connect ball and socket to clevis fittings. Nos. 43058 A-S were specially designed for connecting Alcoa compression type dead-ends and other strain clamps to insulator ball bolts or other ball fittings. No. 43051 has a square shank for ready attachment of arcing horns. Material: Forged steel, except No. 8407, which is malleable iron. All galvanized.

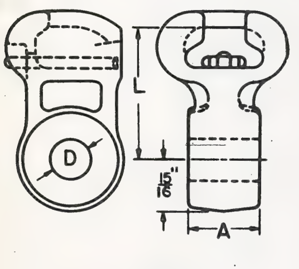


Fig. 1

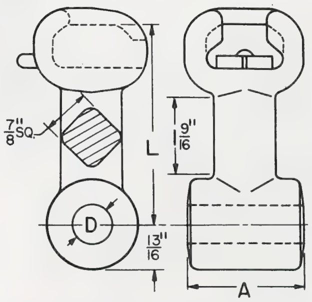


Fig. 2

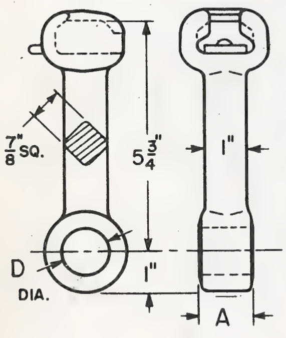


Fig. 3

Catalog Number	Fig. No.	For Alcoa Steel Clevis Series	Dimensions—Inches			Ultimate Strength—Lbs.		Approx. Lbs. per C Pkd.
			A	D	L	Standard	Heat-Treated HT	
8407	1	—	1/2	11/16	2 3/8	18000	—	112
43044	1	—	3/4	13/16	2 7/8	***25000	***35000	103
*43046	1	—	5/8-2 1/8	11/16	2 9/16	***25000	***35000	**178
*43051	2	—	3/4-2 1/16	11/16	3 5/8	***25000	***35000	**231
43058A	3	771	11/16	11/16	—	—	35000	223
43058B	3	772	13/16	13/16	—	—	35000	230
43058C	3	773	1 1/16	1 1/16	—	—	35000	241
43058D	3	774, 775	1 1/4	1 3/16	—	—	35000	242
43058E	3	—	1 1/4	1 5/16	—	—	35000	233
43058S	3	Specify desired "A" and "D" dimensions						

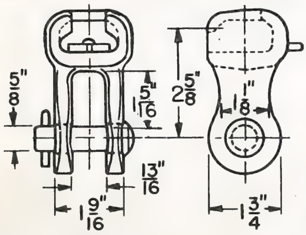
*When ordering, specify tongue thickness required.

**Weight is for maximum tongue width.

***Standard strength furnished, unless heat treating specified on order by adding HT to catalog number.

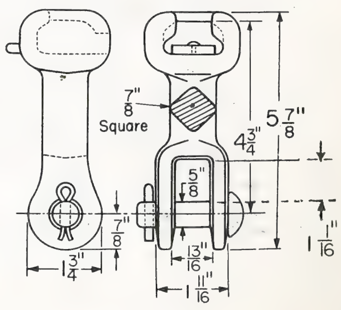
SOCKET CLEVIS
FORGED STEEL

Used to connect ball and socket to eye fittings.



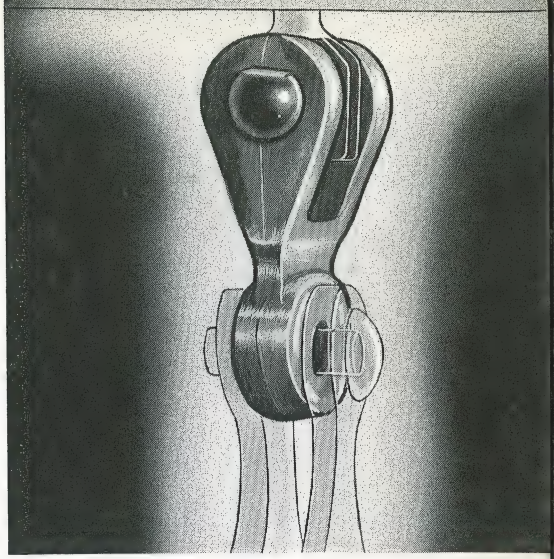
NO. 43040

Catalog No. Std. Strength. For Heat-Treated, Add HT	Ultimate Strength-Lbs.		Approx. Lbs. per C Pkd.
	Std.	Heat-Treated	
43040	20000	30000	135
43065	25000	35000	245



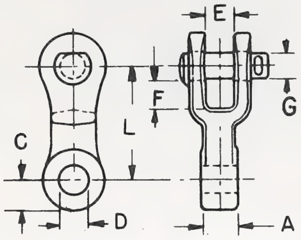
NO. 43065

STRAIN FITTINGS



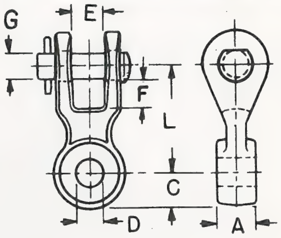
CLEVIS EYE
FORGED STEEL

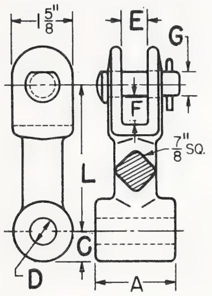
Used to connect eye and clevis fittings. Nos. 43064 A-D were specially designed for connecting Alcoa compression type and other strain clamps to yoke sets or other fittings.



NOS. 43047
43060

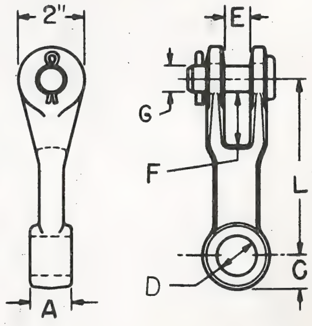
NOS. 43061
43067





NO. 43052

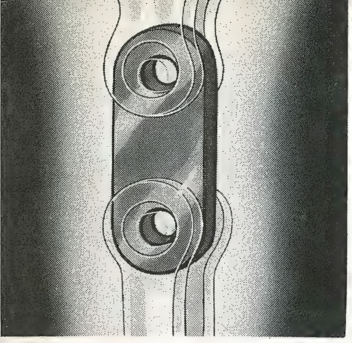
NO. 43064



Catalog Number	For Alcoa Steel Clevis Series	Dimension—Inches							Ultimate Strength—Lbs.		Approx. Lbs. per C Pkd.
		A	C	D	E	F	G	L	Standard	Heat-Treated HT	
*43047	—	5/8-2 3/8	3/4	11/16	11/16	3/4	5/8	2 3/4	25000	35000	178
*43052	—	3/4-2 1/16	13/16	11/16	11/16	3/4	5/8	3 13/16	25000	35000	231
*43060	—	1/2	15/16	13/16	11/16	3/4	5/8	2 15/16	20000	30000	107
*43061	—	1/2	13/16	13/16	11/16	3/4	5/8	2 3/4	20000	30000	108
*43067	—	19/32-1	13/16	11/16	13/16	3/4	5/8	2 9/16	20000	30000	115
43064A	772	3/4	1	13/16	7/8	1 3/4	3/4	5 1/2	36000	—	267
43064B	773	1	1	1 1/16	7/8	1 3/4	3/4	5 1/2	36000	—	275
43064C	774 775	1 1/4	1	1 3/16	7/8	1 3/4	3/4	5 1/2	—	40000	289
43064D	774 775	1 1/4	1	1 3/16	7/8	1 11/16	7/8	5 1/2	—	50000	280

*Standard strength furnished, unless heat treating specified on order by adding HT to catalog number.

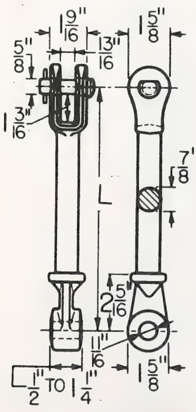
For Nos. 43047, 43052 and 43067, specify required A dimension on order.



SUSPENSION AND

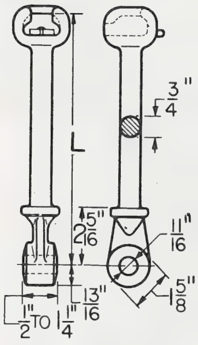
EXTENSION LINK
STEEL

Used for providing increased clearances and similar applications.
Nos. 43063 and 43066 are forged.



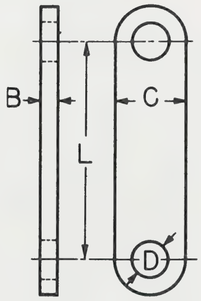
1 9/16"
1 5/8"
5/8"
13/16"
1 3/16"
7/8"
L
2 5/16"
11/16"
1/2" TO 1 1/4"
5/8"

NO. 43063

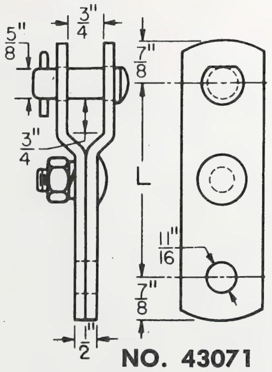


3/4"
L
2 5/16"
11/16"
1 5/8"
1/2" TO 1 1/4"
13/16"

NO. 43066

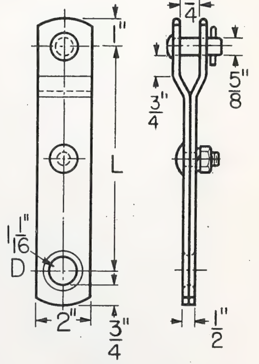


NO. 43070



5/8"
3/4"
7/8"
3/4"
L
11/16"
7/8"
1/2"

NO. 43071



3/4"
1"
5/8"
3/4"
L
1 1/16"
D
2"
3/4"
1/2"

NOS. 43074A TO 43074E

Catalog No. Std. Strength. For Heat-Treated, Add HT	L Inches	Ultimate Strength—Lbs.		Approx. Lbs. per C Pkd.
		Standard	Heat-Treated—HT	
43063	10	20000	30000	237
43066	10¼	20000	30000	252
43070		See Notes		
43071	—	18000	25000	—
43074A	8	18000	25000	288
43074B	10	18000	25000	345
43074C	12	18000	25000	401
43074D	6	18000	25000	232
43074E	20	18000	25000	631

Nos. 43063 and 43066
Tongue thickness varies ½" to 1¼". Specify on order. Weight is for max. tongue thickness.

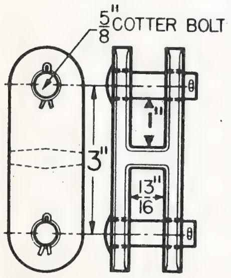
No. 43070
Generally available in ⅜" x 1½" stock. Ult. strength and weight vary with size of steel. Specify B, C, D and L dimensions.

No. 43071
Can be furnished in any length (L) from 3" up. Specify length required. Weight varies with length.

CLEVIS CLEVIS

Used for providing increased clearances and similar applications.
Material: No. A-1425—Malleable iron.
No. 43072—Steel.

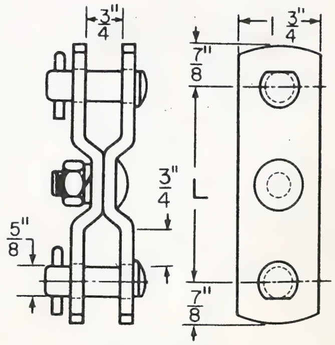
No. 43072
Can be furnished in any length (L) from 4" up. Specify length required. Weight varies with length.



5/8" COTTER BOLT
3"
1"
13/16"

NO. A-1425

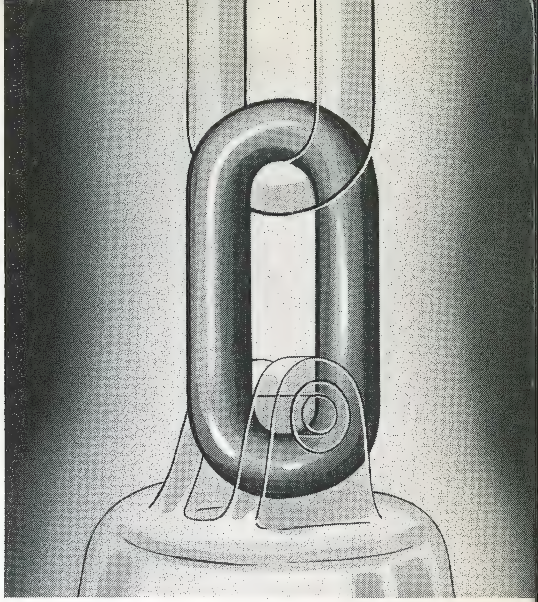
Catalog No. Std. Strength. For Heat-Treated, Add HT	Ultimate Strength-Lbs.		Approx. Lbs. per C Pkd.
	Standard	Heat-Treated—HT	
A-1425	25000	—	210
43072	18000	25000	—



3/4"
1 3/4"
7/8"
3/4"
L
5/8"
7/8"

NO. 43072

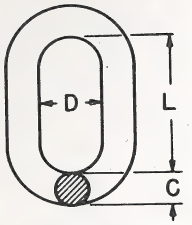
STRAIN FITTINGS



LINK
FORGED STEEL

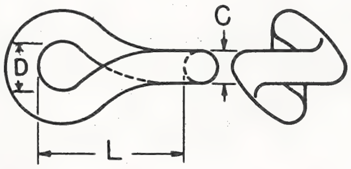
Used to obtain slight increases in clearance and for adapting other fittings at special locations.

LINK



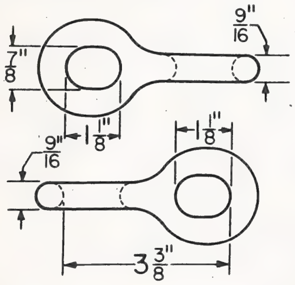
NOS. 43080-43083

TWISTED LINK

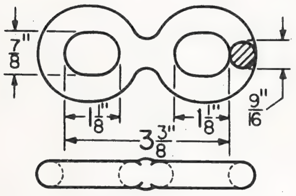


NOS. 43080-T - 43083-T

DOUBLE EYE LINK


9"/16
7"/8
1 1"/8
1 1"/8
9"/16
3 3"/8

RIGHT ANGLE TWIST
NO. 43085

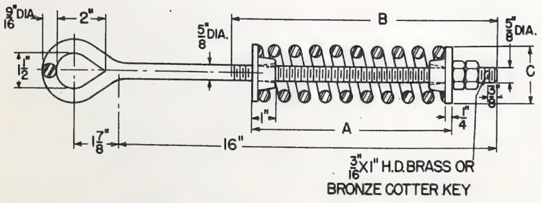

7"/8
1 1"/8
1 1"/8
9"/16
3 3"/8

STRAIGHT
NO. 43086

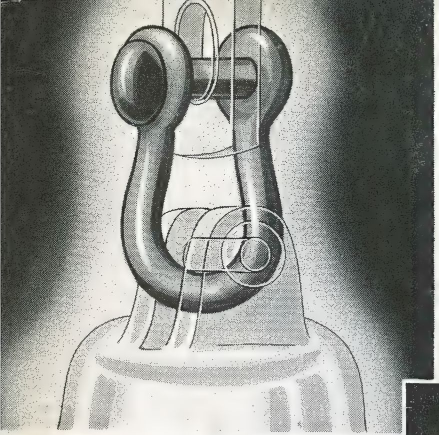
Catalog Number Standard Strength. For Heat-Treated, add HT	Dimensions—Inches			Ultimate Strength—Lbs.		Approx. Lbs. per C Pkd.
	C	D	L	Standard	Heat-Treated HT	
43080	½	1	2¼	20000	30000	51
43081	½	1¹⁄₁₆	2⅜	20000	30000	51
43082	⅝	1	3¼	25000	35000	101
43083	¾	1	3½	35000	50000	134
43080-T	½	1	2	20000	30000	51
43081-T	½	1¹⁄₁₆	2³⁄₁₆	20000	30000	51
43082-T	⅝	1	3	25000	35000	101
43083-T	¾	1	3⁵⁄₁₆	35000	50000	134
43085	See Drawing			18000	25000	76
43086	See Drawing			18000	25000	76

SPRING BOLT

For use where controlled tension is required. By adding a socket—or ball-clevis, may be attached to ball-and-socket insulators. "A" dimension given with no loading on spring.


9"/16 DIA.
2"
5"/8 DIA.
B
5"/8 DIA.
1 1"/2
C
3"/8
1"
1"/4
A
1 7"/8
16"
3"/16 X 1" H.D. BRASS OR BRONZE COTTER KEY

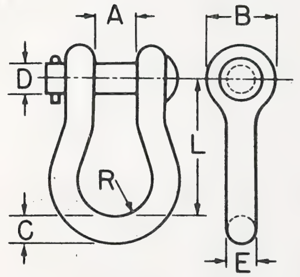
Catalog Number	Tension Range Lbs.	Dimensions-Inches			Free Length Inches	Approx. Lbs. per C Pkd.
		A	B	C		
41222	0-2250	8½	11¼	2⅜	8	725
41223	0-5270	10½	12¾	3½	10	1685



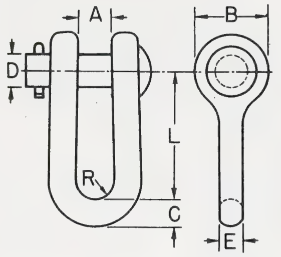
SUSPENSION AND

SHACKLE
FORGED STEEL

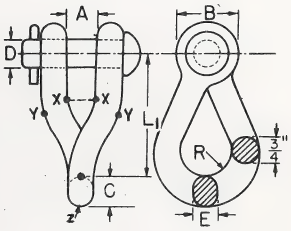
Used for tower connections and other general applications. Twisted shackles should be checked for assembly clearance with parts to which they are to be connected. Interference at X-X, Y-Y or Z (See drawing) may make assembly impossible. If desired, we will send sample on receipt of complete dimensions of connecting parts.



ANCHOR TYPE



CHAIN TYPE

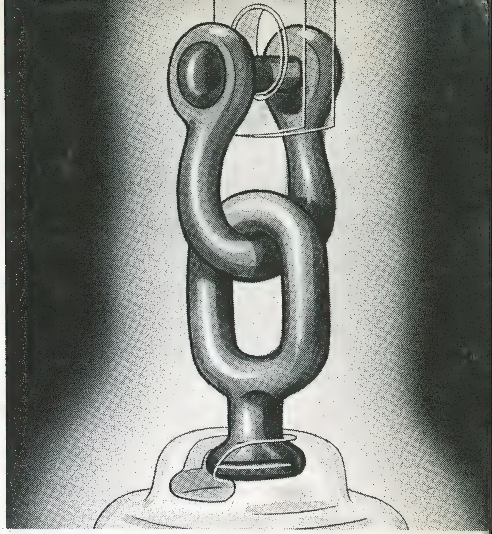


TWISTED
("T" after catalog number)

Catalog Number		Dimensions—Inches								*Ult. Strength—Lbs.		Approx. Lbs. per C Pkd.
ANCHOR TYPE												
Regular	Twisted	A	B	C	D	E	L	L_1	R	Standard	Heat-Treated HT	
43019	43019T	¾	1¼	½	9/16	½	2 3/16	2	11/16	18000	25000	85
43020	43020T	¾	1 5/16	½	9/16	½	2 25/32	2½	21/32	18000	25000	81
43021	43021T	⅞	1¼	9/16	⅝	9/16	2 3/16	2	11/16	18000	25000	85
43022	43022T	¾	1¼	½	⅝	½	2 3/16	2	11/16	18000	25000	100
43023	43023T	1 1/16	1¾	⅝	¾	⅝	2 25/32	2½	¾	25000	35000	150
43024	43024T	¾	1 5/16	½	⅝	½	2 25/32	2½	21/32	18000	25000	75
43025	43025T	⅞	1¾	⅞	¾	¾	3½	3¼	¾	30000	45000	205
43027	43027T	¾	1⅞	¾	¾	¾	5	4¾	11/16	35000	50000	270
CHAIN TYPE												
Regular	Twisted											
43017	43017T	¾	1¼	½	9/16	½	1 31/32	1 11/16	⅜	18000	25000	70
43018	43018T	1 1/16	1 9/16	⅝	¾	⅝	2½	2¼	17/32	25000	35000	140
43026		⅞	1⅞	¾	⅞	⅝	3⅜	3⅛	½	35000	50000	245

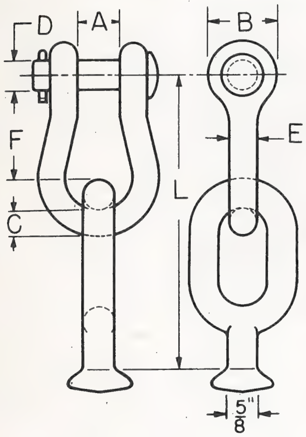
* Standard strength furnished unless heat treating specified on order by adding HT to catalog number.

STRAIN FITTINGS



TOWER FITTINGS
FLEXIBLE TYPE— FORGED STEEL

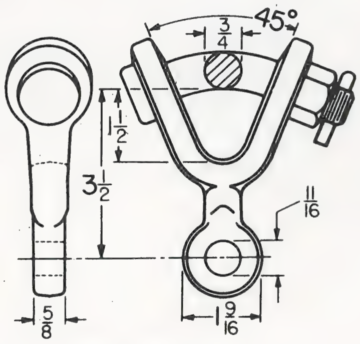
Used for attaching insulators to supporting structure, where a strong, flexible connection is required.



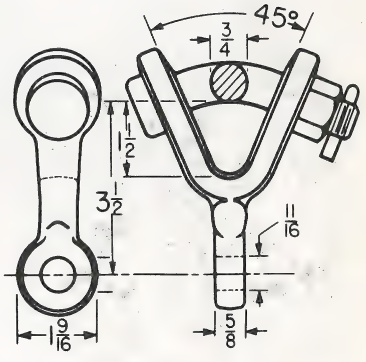
Catalog Number	Dimensions—Inches							Ultimate Strength Pounds	Approx. Lbs. per C Pkd.
	A	B	C	D	E	F	L		
43014-43024	3/4	1 5/16	1/2	5/8	1/2	1 13/16	6 1/32	18,000	175
43014HT-43023	1 1/16	1 7/16	5/8	3/4	5/8	1 25/32	6 1/32	25,000	250
43014HT-43025	7/8	1 3/4	7/8	3/4	3/4	2 1/4	6 3/4	30,000	305

TOWER FITTINGS
"Y" TYPE— FORGED STEEL

Used for attaching insulators to tower structures.

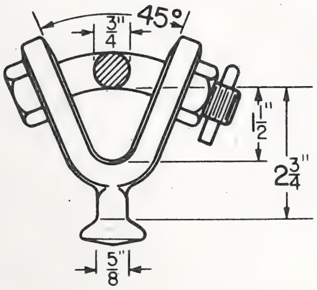


NO. 43031



NO. 43032

"Y" Clevis Eye



NO. 43030

"Y" Clevis Ball

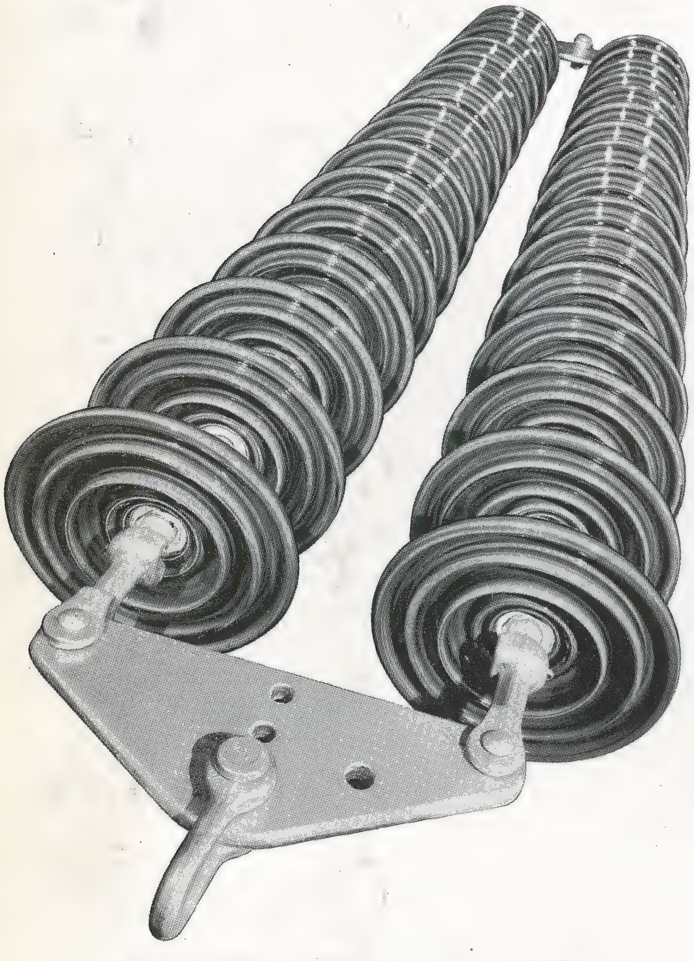
Catalog No. Std. Strength. For Heat-Treated, Add HT.	Ultimate Strength—Lbs.		Approx. Lbs. per C Pkd.
	Standard	Heat-Treated HT	
43030	18000	25000	200
43031	20000	30000	200
43032	20000	30000	200

DOUBLE STRAIN YOKE SET
BALL-SOCKET

SUSPENSION AND

All plates and fittings of standard ball-socket sets with 13″ and 16″ spacings are drop forged from C-1038 steel.

Die-forged yoke plates with full radius edges and corners are superior to sheared or flame-cut plates in finish, appearance, strength and corona performance. Upper assembly has all-direction flexibility. All holes drilled and burred, all socket openings fully machined. Lower plate-to-insulator connectors are long enough to develop the full flashover value of the insulator string.



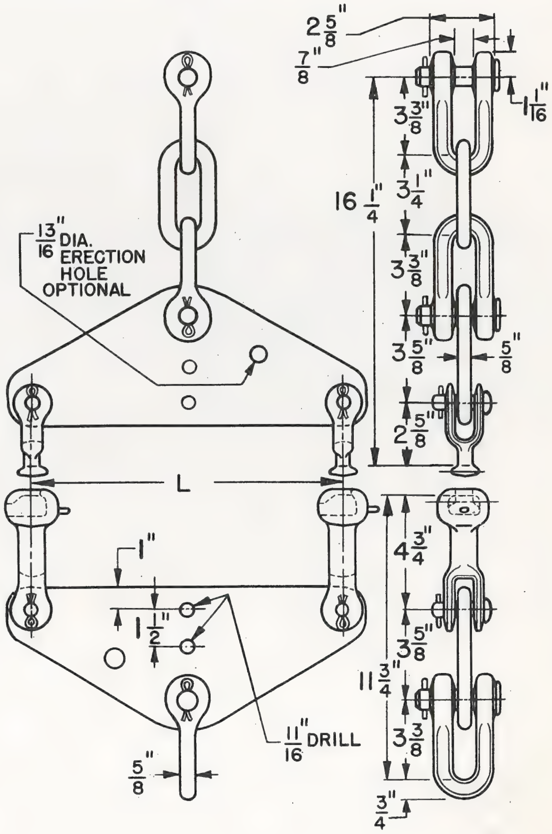
Catalog Number	L Inches	Mechanical Strength Lbs.	Approx. Lbs. per C Pkd.
48700	13	36000	3600
***48750**	13	50000	3600
48720	16	36000	4100
***48770**	16	50000	4100

*All parts are heat-treated.

Dimensions of both strength classes are the same, the higher strength being obtained by heat-treatment without weight increase. Forged steel parts are smoothly hot-dip galvanized.

Shackle clevises Nos. 43023, 43025 or 43026 may be substituted for No. 43027 shown on upper and lower assemblies and Clevis Eye No. 43064 (for attachment of compression and similar type strain clamps) for the No. 43027 on the lower assembly.

Position of holes in plates for attachment of grading devices and erection tools may be changed from standard drilling shown. See page 87 for arcing horns. Special arcing horns or rings can be supplied.



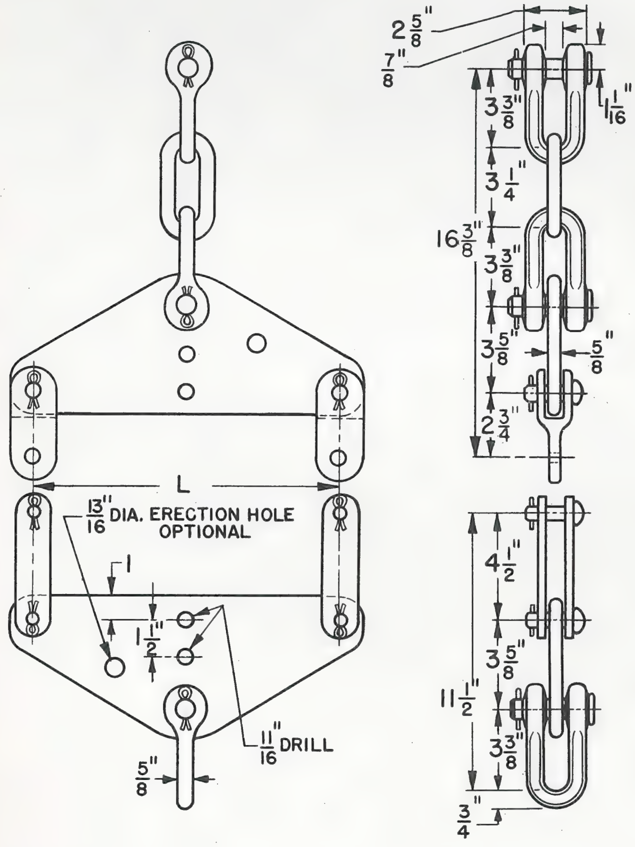
STRAIN FITTINGS

DOUBLE STRAIN YOKE SET

CLEVIS TYPE

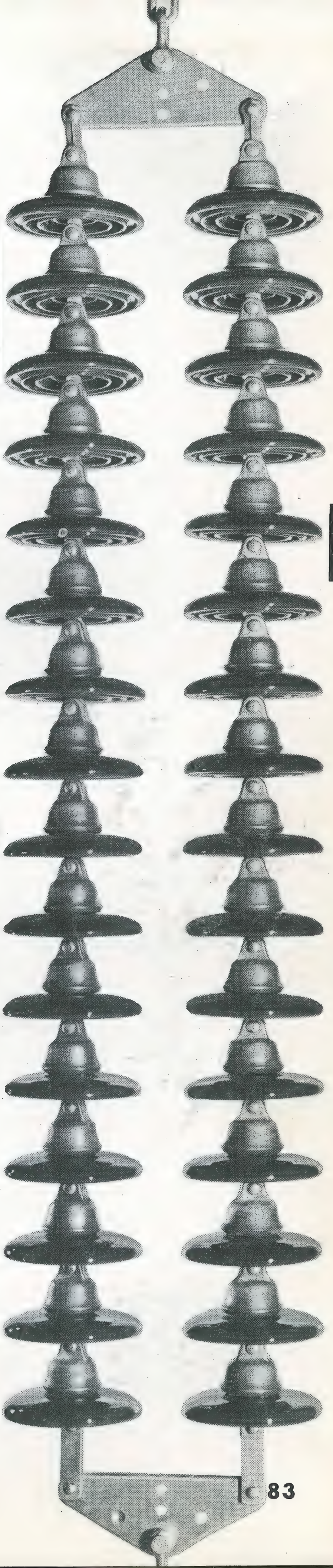
All plates and fittings of clevis-type sets with 13″ and 16″ spacings are drop forged from C-1038 steel.

These assemblies are identical with the ball-socket types shown on opposite page with exception of the clevis-type fittings for insulator attachment. For further specifications and interchange of fittings, see description for ball-socket assemblies.

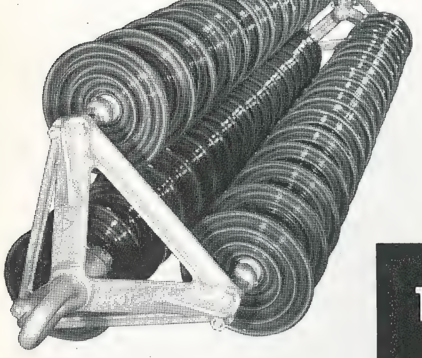

2 5/8"
7/8"
3 3/8"
1 1/16"
3 1/4"
16 3/8"
3 3/8"
3 5/8"
5/8"
2 3/4"
4 1/2"
3 5/8"
11 1/2"
3 3/8"
3/4"
L
13/16" DIA. ERECTION HOLE OPTIONAL
1
1 1/2"
11/16" DRILL
5/8"

Catalog Number	L Inches	Mechanical Strength—Lbs.	Approx. Lbs per C Pkd.
48800	13	36000	3800
***48850**	13	50000	3800
48820	16	36000	4300
***48870**	16	50000	4300

*All parts are heat-treated.



SUSPENSION AND



TRIPLE STRAIN YOKE SET

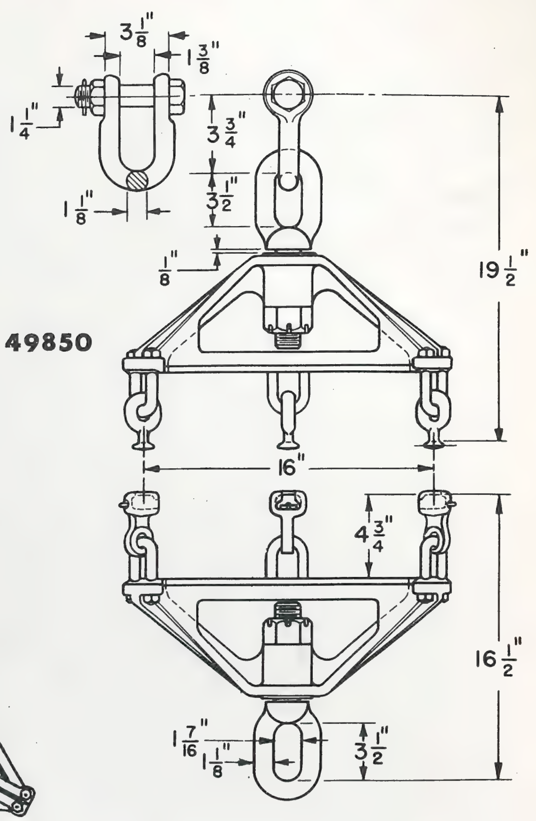
Standard ball-socket and clevis-type sets with the most commonly specified 16″ insulator string spacing are illustrated.

Yoke plates are heat-treated, specification steel castings. Fittings are drop forged from C-1038 Steel, heat-treated for uniformly high strength. U-Bolts are No. 1045 Steel, heat-treated. The design gives all-direction flexibility and self-equalization of insulator string loadings. All load-bearing holes are drilled and burred, and all socket openings fully machined. Lower plate-to-insulator linkage is sufficiently long to develop the full flashover value of the insulator string. U-Bolt nuts are securely locked in position by ribs on the yoke casting. All steel parts are thoroughly and smoothly hot-dip galvanized, free of corona-producing sharp edges and surface roughness.

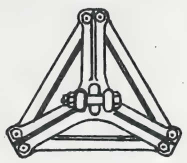
Arcing horns or rings can be supplied and provisions made for the attachment of grading devices, on special order. Information on request.

If standard shackle, clevis or eyebolt shown do not meet construction requirements, it is generally possible to substitute other, more suitable parts for which production equipment is available. In such cases, full construction details should be furnished.

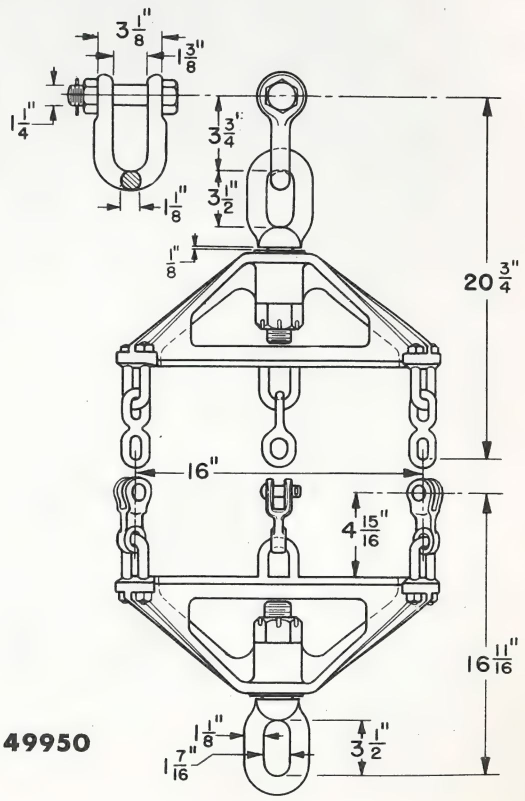
Catalog Number	Mechanical Strength—Lbs.	Approx. Lbs. per C Pkd.
49850	75000	11000
49950	75000	11000



NO. 49850



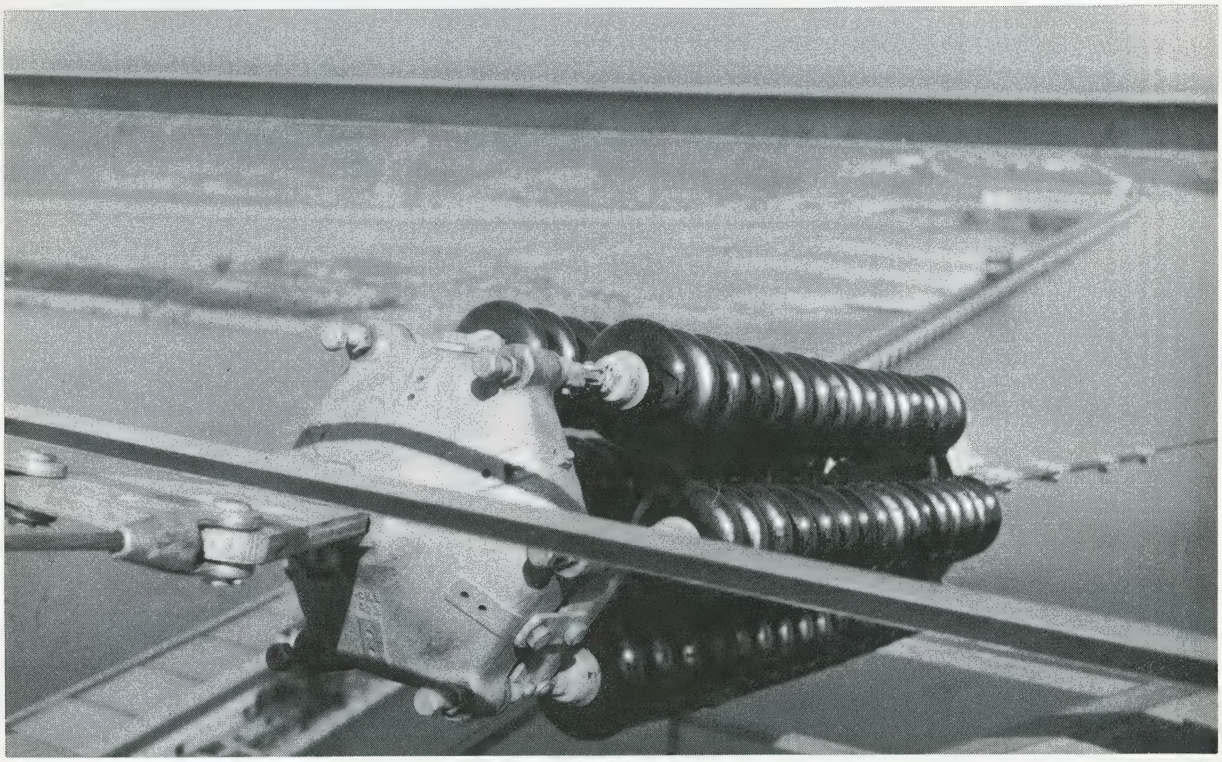
Top View



NO. 49950

STRAIN FITTINGS

SPECIAL PURPOSE YOKE SETS



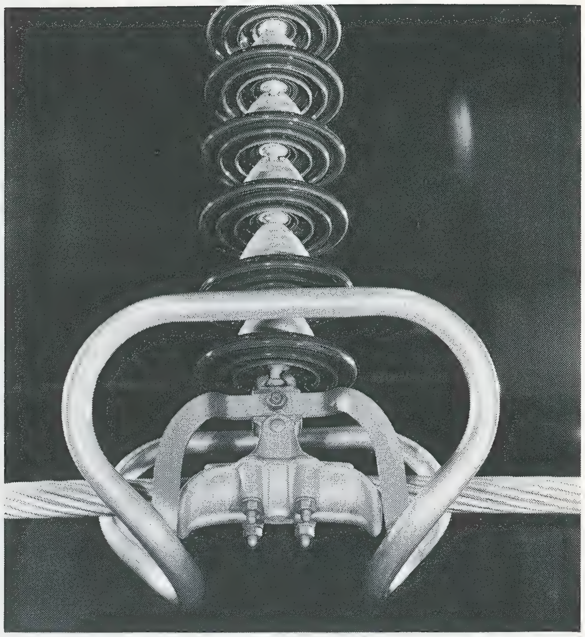
Six string Locke yoke in use on wide river crossing. Note adjustable bolts around top yoke to facilitate removal of any individual insulator string.

For special applications, requiring greater strength than that of triple strain yoke sets, we are in a position to furnish multiple strain yoke sets. These may be similar to the design illustrated above or of any design required for the particular purpose. Locke special purpose multi-strain yoke sets are in use on many important installations.

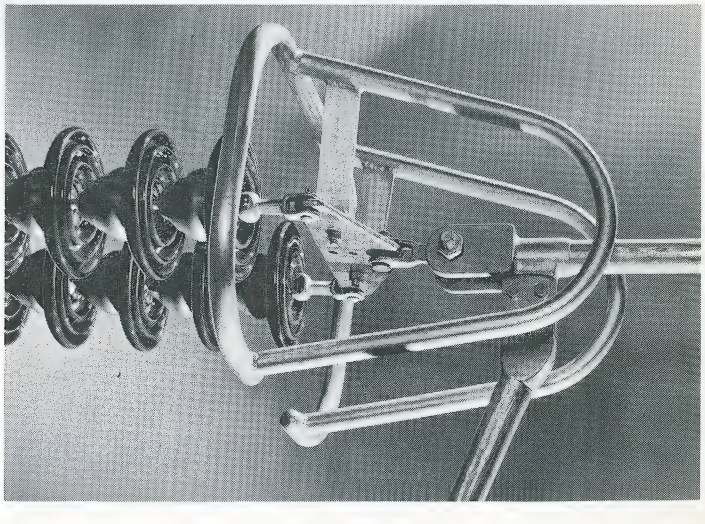
SUSPENSION

CORONA SHIELDS

Corona shields are usually used at voltages above 230 KV to improve voltage distribution among the units of long insulator strings. They suppress corona and radio noise on the hardware of the units and shield suspension, strain clamps and lower yokes from high voltage gradients. Locke corona shields are simple to attach and permit easy hot line maintenance. Qualified Locke engineers are at your service in respect to these corona shields or modifications to fit your requirements on extra high voltage lines. Please contact your nearest Locke Representative.

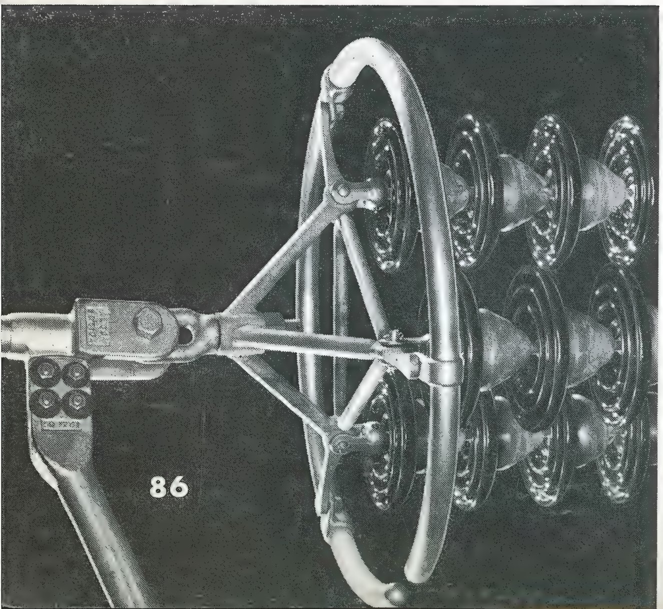


Single suspension assembly, used for 330 KV application.

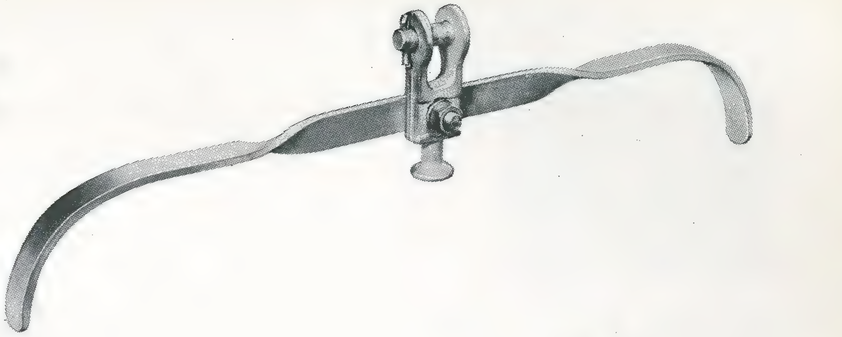


Double strain assembly, used for 330 KV application.

Triple dead-end assembly, used for 345 KV application.



FITTINGS

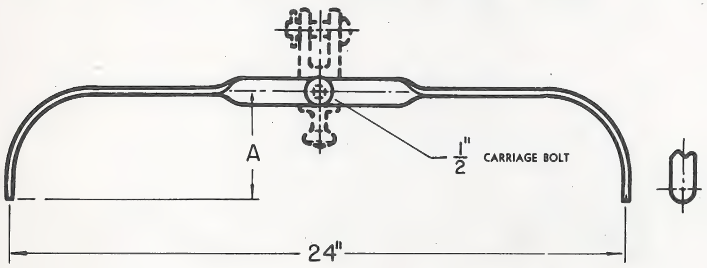


ARCING HORNS

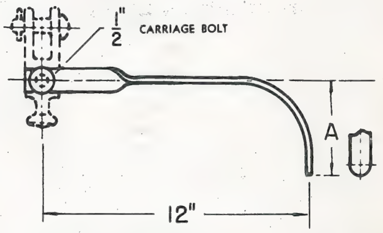
Simple strap arcing horns provide an economical method of reducing danger of flash-over damage to conductor and insulators. The single-hole horns are designed for easy installation and the complete line of supporting fittings assures permanent and tight attachment in the desired position. The horn-fitting assembly adds no undesirable weight to the vibration-oscillated portion of the clamp assembly.

Standard horns are made from ¼″ x 1″ flat steel, hot-dip galvanized. Attachment bolts, nuts and lockwashers are included. Standard lengths, 24″ for full horns and 12″ for half horns, are recommended. Other lengths can be supplied.

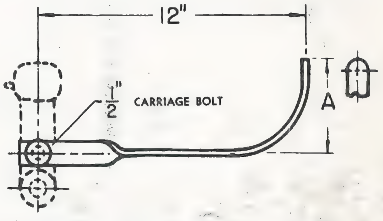
After choosing supporting fitting, DETERMINE DIMENSION "A" AND SPECIFY ON ORDER. Suitable horns and fittings will gladly be recommended on receipt of complete data as to line voltage, number and type of insulators in string, details of tower attachments and suspension or strain clamps. Spherical curled-end or spherical-tipped horns and arcing rings, made from flat, round, structural or tubular steel as well as special drop forged fittings will be produced on your request.



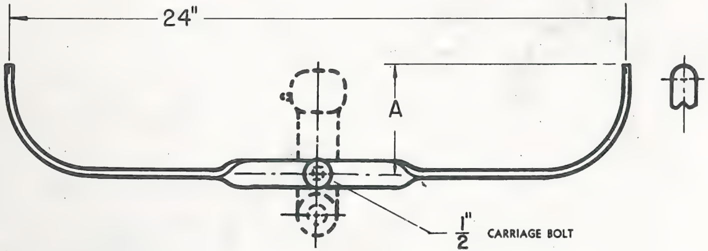
TYPE 4605
Upper full horn (Suspension String) for attachment to fittings Nos. 43100, 43101, 43102, 43103, 43104, 43105, 43120 and 43121.



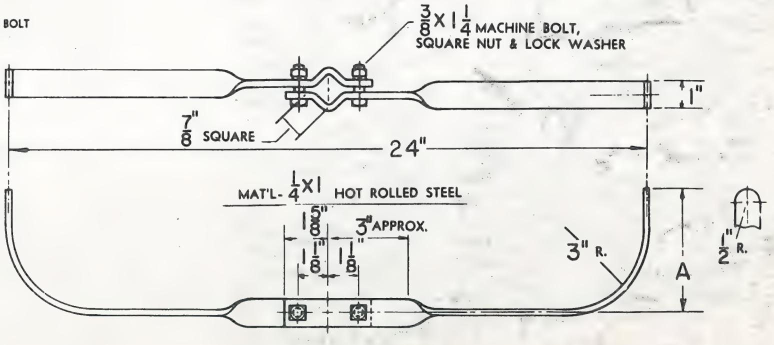
TYPE 4607
Upper half horn (Single Strain String) for attachment to fittings Nos. 43100, 43101, 43102, 43103, 43104, 43105, 43120 and 43121.



TYPE 4608
Lower half horn (Single Strain String) for attachment to fittings Nos. 43110, 43120 and 43121.

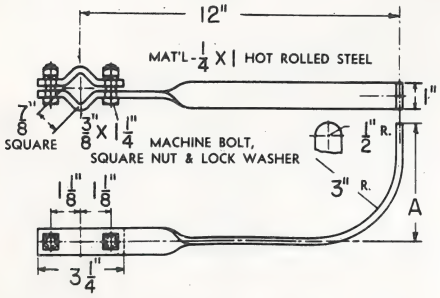


TYPE 4606
Lower full horn (Suspension String) for attachment to fittings Nos. 43110, 43120 and 43121.

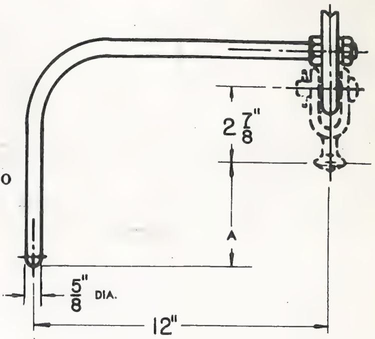

⅜ x 1¼ MACHINE BOLT, SQUARE NUT & LOCK WASHER
1"
⅞" SQUARE
24"
MAT'L- ¼ x 1 HOT ROLLED STEEL
1⅝"
3" APPROX.
1⅛"
1⅛"
3" R.
A
½" R.

TYPE 4609
Lower full horn (Suspension String) for attachment to square-shank connectors.

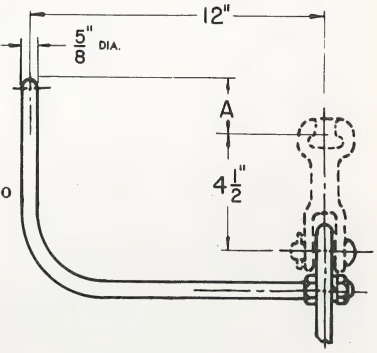
ARCING HORNS
STEEL (CONT.)


12"
MAT'L-1/4 X 1 HOT ROLLED STEEL
1"
7/8 SQUARE
3/8 X 1 1/4 MACHINE BOLT, SQUARE NUT & LOCK WASHER
1/2" R.
3" R.
A
1 1/8" 1 1/8"
3 1/4"

TYPE 4610
Lower half horn (Single Strain String) for attachment to square-shank connectors on strain clamps shown on page 58.

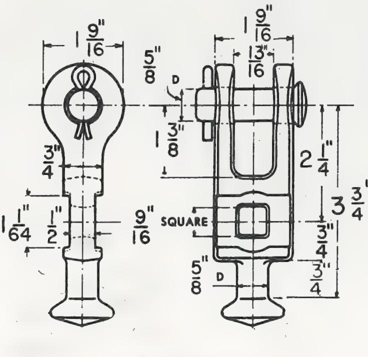

2 7/8"
A
5/8" DIA.
12"

TYPE 4611
Upper half horn for attachment to upper strain yoke set plate.

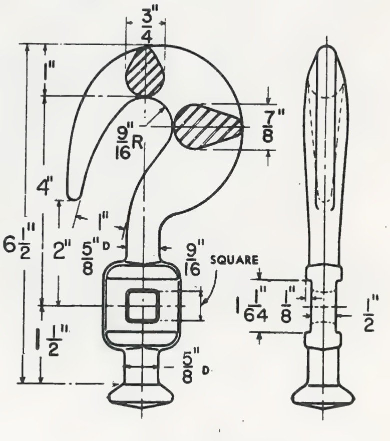

12"
5/8" DIA.
A
4 1/2"

TYPE 4612
Lower half horn for attachment to lower strain yoke set plate.

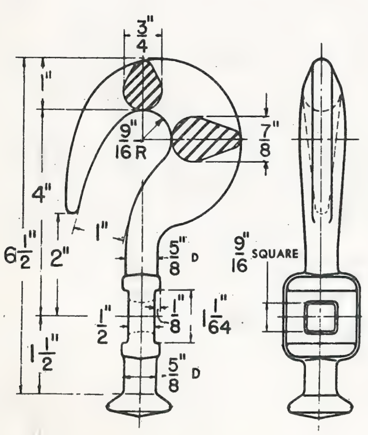
ARCING HORN FITTINGS
FORGED STEEL


1 9/16"
5/8" D
1 13/16"
3/4"
1 3/8"
2 1/4"
3 3/4"
1 1/64
1/2"
9/16" SQUARE
3/4"
5/8" D
3/4"

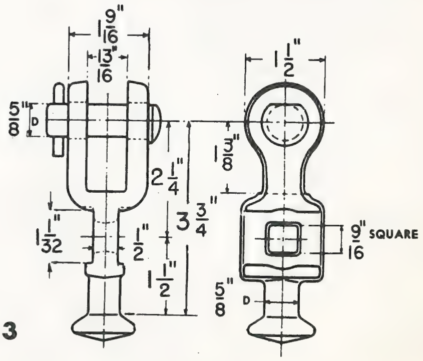
NO. 43100


3/4"
1"
7/8"
9/16" R
4"
6 1/2"
2"
1"
5/8" D
9/16 SQUARE
1 1/64
1/8"
1/2"
1 1/2"
5/8" D

NO. 43101


3/4"
1"
9/16 R
7/8"
4"
6 1/2"
2"
1"
5/8" D
9/16" SQUARE
1/2"
1/8"
1 1/64
1 1/2"
5/8" D

NO. 43102

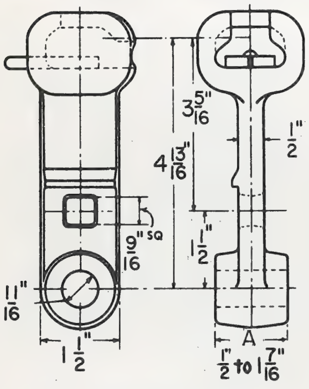

1 9/16"
1 13/16"
1 1/2"
5/8" D
1 3/8"
2 1/4"
3 3/4"
1 1/32
1/2"
9/16" SQUARE
1 1/2"
5/8" D

NO. 43103

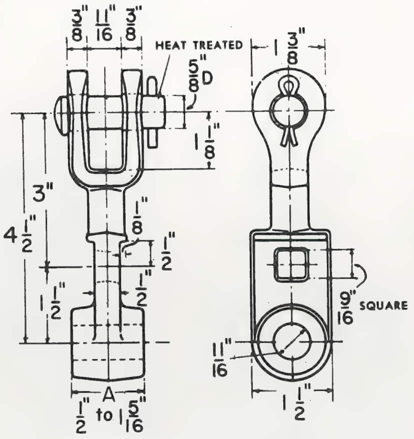
FITTINGS

ARCING HORN FITTINGS FORGED STEEL (CONT.)

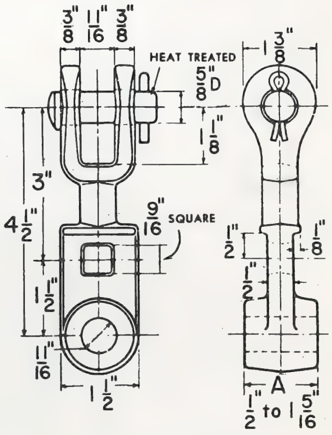
These fittings are designed for use with arcing horns shown on previous pages. Be sure to specify "A" dimension on your order, where required.


3 5/16"
4 13/16"
1/2"
9/16" SQ
1 1/2"
11/16"
1 1/2"
A
1/2" to 1 7/16"

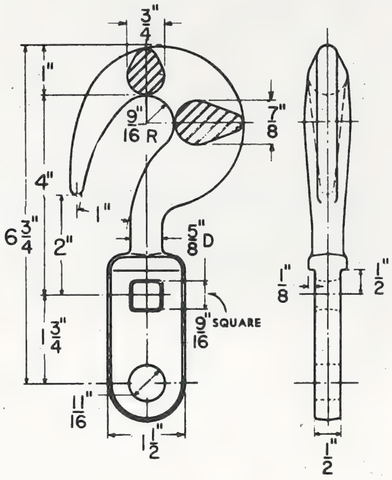
NO. 43110


3/8" 11/16" 3/8"
HEAT TREATED
5/8" D
1 3/8"
1 1/8"
3"
4 1/2"
1/8"
1/2"
1/2"
1 1/2"
A
1/2" to 1 5/16"
9/16" SQUARE
11/16"
1 1/2"

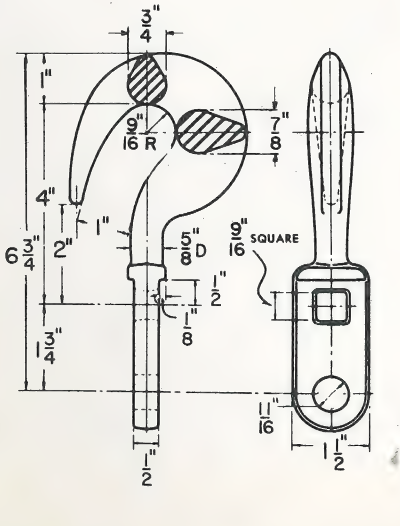
NO. 43120


3/8" 11/16" 3/8"
HEAT TREATED
5/8" D
1 3/8"
1 1/8"
3"
4 1/2"
9/16" SQUARE
1/2"
1/8"
1/2"
1 1/2"
11/16"
1 1/2"
A
1/2" to 1 5/16"

NO. 43121


3/4"
1"
9/16" R
7/8"
4"
1"
6 3/4"
2"
5/8" D
1/8"
1/2"
9/16" SQUARE
1 3/4"
11/16"
1 1/2"
1/2"

NO. 43104


3/4"
1"
9/16" R
7/8"
4"
1"
6 3/4"
2"
5/8" D
9/16" SQUARE
1/2"
1/8"
1 3/4"
11/16"
1 1/2"
1/2"

NO. 43105

Catalog Number*	Ultimate Strength		Approx. Lbs. per C Pkd.	A* Inches
	Not Heat Treated	Heat Treated		
43100	18000	25000	95	—
43101	18000	25000	180	—
43102	18000	25000	180	—
43103	18000	25000	98	—
43110	20000	30000	225	½ to 1 7/16
43120	18000	25000	135	½ to 1 5/16
43121	18000	25000	135	½ to 1 5/16
43104	18000	25000	220	—
43105	18000	25000	220	—

* Specify dimension "A". Quotations on widths above maximum on request.

PIN TYPE

NEMA Standard Low Voltage Pin Type Insulators.

BUILT FOR LONG SERVICE

Locke Pin Type insulators are designed for rugged service on distribution lines. Made of finest porcelain, they maintain excellent electrical characteristics indefinitely . . . some are still in use after 47 years' service (see photo, page 6). Heavy blows may cause chipping or breaking of petticoats but seldom such damage that the conductor is no longer supported. Pin hole quality is determined by statistical sampling methods used in routine production and inspection (see photo, page 22). Low voltage pin type insulators may be used with wood or steel crossarms or pole top pins. At higher voltages, modern practice favors steel pins, as leakage currents over the insulator may char or burn wood pins.

YOU BENEFIT BY EEI-NEMA STANDARD

The design and specifications of all Locke Pin Type insulators, except where "special application" is noted, conform with joint specifications TDJ-55 of EEI and NEMA (see page 105). The reason for writing this specification was the expressed need by utility insulator users for standardization on insulators which would meet the requirements of their majority. By eliminating many former designs, they reduced procurement and stocking problems. By concentrating production on fewer types, manufacturers are able to give better service. Where special non-standard insulators are required, consult your Locke representative.

DATA TABLE NOTES

RADIO INFLUENCE VALUES

The Radio Influence Values in the tables apply only to new pin type insulators, tested in the factory, and are the maximum microvolt ratings when tested at the indicated test voltage to ground. Tests are made in accordance with current NEMA-EEI-RMA recommendations on methods of measuring radio noise, NEMA publication #107, and AIEE specification #41, ASA C-29.1-1944, (page 204) or latest revisions. The low frequency RMS test voltage values are approximately 10% higher than the line to ground voltage at which these insulators are usually operated.

HIGH RESISTANCE COATINGS

Where high-resistance coatings are applied, the distance over such coatings is considered effective leakage distance. Due to their semiconduction, low frequency dry flashover values of radio noise freed types may vary up to 5 KV from indicated values.

PIN HOLES

High voltage pin-type insulators are furnished standard with 1⅜″ diameter metal threaded pinholes, formed by zinc shell thimbles, cemented into sanded pin holes. Low voltage pin-type insulators are furnished standard with 1″ diameter glazed pin holes, formed in the porcelain. They are checked with the standard NEMA pin hole gauge. (See joint EEI-NEMA Std. TDJ-55, page 105.)

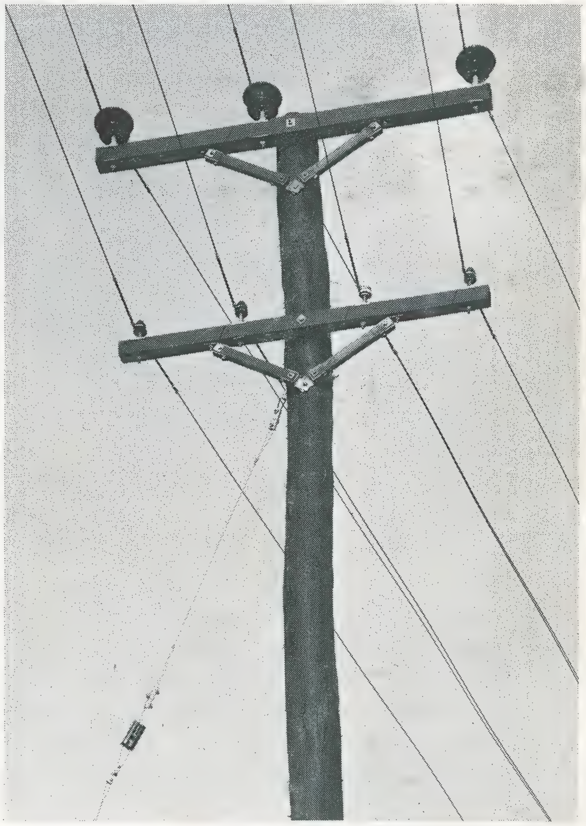
RADIO NOISE FREED PIN TYPES

For more details, see page 16.

All EEI-NEMA Standard pin-type insulators are furnished radio noise freed unless otherwise specified. This is achieved by the use of semi-conducting Locke Metaglaze (See page 10).

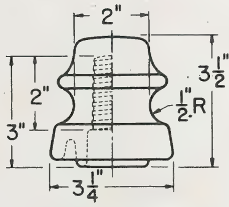
On low-voltage one-piece pin-type insulators, the semi-conducting coating is applied to wire groove surfaces and pin holes (See illustrations on pages 22 and 23). The conducting coating reduces the possibility of corona formation at operating voltages across small air spaces between conductor and wire groove surfaces, as well as between metal pins and pin hole surfaces. The area covered by the permanent conducting glaze remains at approximately the same potential as the adjacent metal surface, short-circuiting corona discharges and reducing radio noise. Due to this property, the low frequency flashover values of radio noise freed pin-type insulators may vary up to 5 KV from indicated values.

The metallic shell cemented into pin holes of high voltage pin types makes the conducting coating of their pin holes unnecessary.

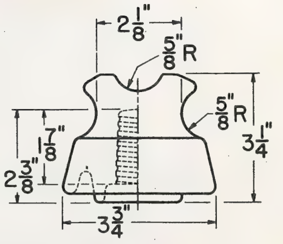


JOINT EEI-NEMA
PIN TYPE
FOR 23 KV

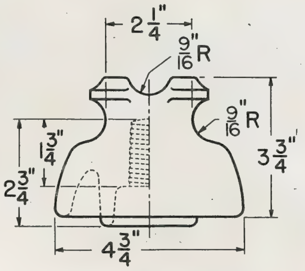
ONE PIECE
LOW VOLTAGE
RADIO NOISE FREED


2"
3 1/2"
2"
1/2" R
3"
3 1/4"

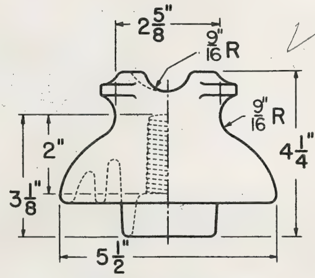
NO. 44NP


2 1/8"
5/8" R
5/8" R
1 7/8"
3 1/4"
2 3/8"
3 3/4"

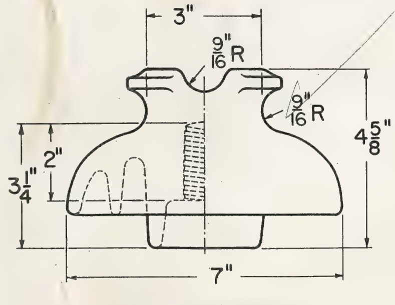
NO. 2NP


2 1/4"
9/16" R
9/16" R
1 3/4"
3 3/4"
2 3/4"
4 3/4"

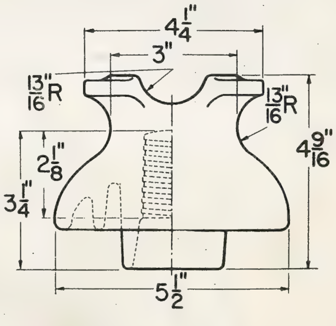
NO. 9995NP


2 5/8"
9/16" R
9/16" R
2"
4 1/4"
3 1/8"
5 1/2"

NO. 6510NP


3"
9/16" R
9/16" R
2"
4 5/8"
3 1/4"
7"

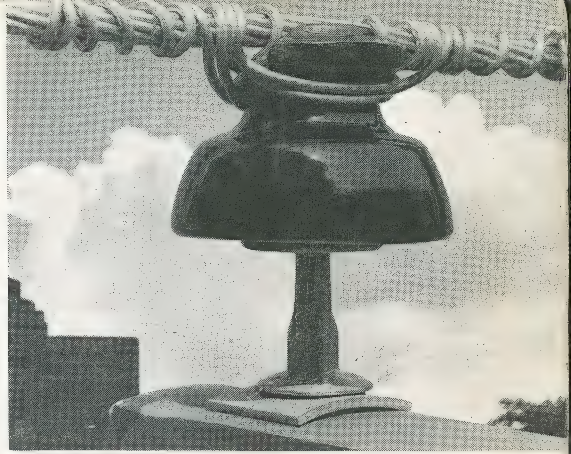
NO. 23514NP


4 1/4"
3"
13/16" R
13/16" R
2 1/8"
4 9/16"
3 1/4"
5 1/2"

NO. 23583NP

NON-STANDARD
WIDE GROOVES
FOR SPECIAL APPLICATIONS

STANDARD TDJ-55 INSULATORS OR BELOW



These insulators are primarily used on rural and urban distribution circuits for voltages below 23 KV. They meet the specifications of the joint EEI-NEMA Standard TDJ-55 for low voltage pin-type insulators. Standardization on these five radio noise freed insulators, which will meet all requirements in their voltage range, can mean substantial savings to you. The basic design of these insulators employs the principle of 'protected leakage' distance, as contrasted with the exposed leakage distance of 'high top' insulators.

CONDUCTOR GROOVES

The smooth, deep, bell mouthed top wire grooves of these standard insulators will accommodate conductors up to 336,400 CM TBWP all aluminum conductor or 4/0 ACSR with armor rods. The deep, well-formed side wire groove provides positive support for conductors placed here for angles and will take conductors as large as 4/0 ACSR with armor rods. For larger conductors, special large wire groove insulators such as Cat. No. 23583 NP, can be obtained.

CONSTRUCTION FEATURES

1. The deep, open corrugations develop full leakage distance and prevent bridging during rain.

2. The inner petticoat flares out quickly from pin. This assures freedom of arcing from tip of inner skirt to pin, making insulator leakage distance fully effective (see photo, page 22).

3. The controlled application of Locke Metaglaze and compression glaze assures high resistance to damage from thermal shock and mechanical impact while maintaining excellent electrical and radio noise characteristics. It permits rough handling of Locke insulators in construction with much less danger of chipping or breaking. Brown glaze is standard. Other colors available on request. For further information on Metaglaze and radio noise freedom, see page 10.

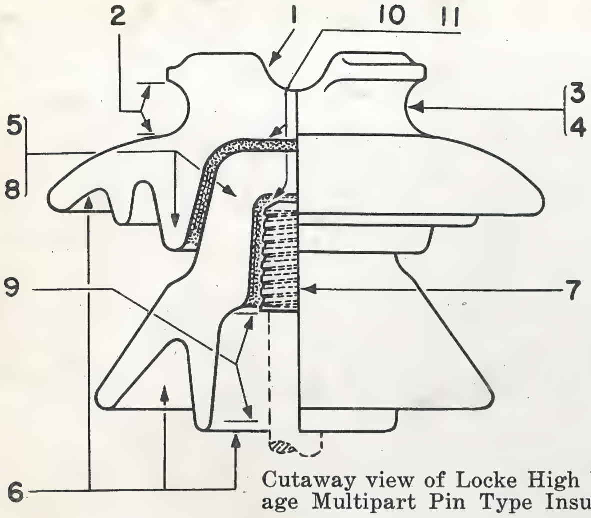
MINIMUM MANDREL SEATED BY CONDUCTOR GROOVES				
	44NP 2NP 9995NP	15/16″ 1 3/16″ 1 1/16″	6510NP 23514NP 23583NP	1 1/16″ 1 1/16″ 1 9/16″

All Insulators have 1″ pin hole threads—wire groove radii are nominal—See Data Table Notes, page 90.

Catalog Number	EEI Class No.	Min. Pin Height Inches	Radio Influence Voltage at 1000 Kc		Flashover—KV				Low Freq. Puncture Voltage KV	Dry Arcing Distance Inches	Leakage Distance Inches	Cantilever Strength Lbs.	Weight Each-Lbs.		Std. Pkd. Quan.
					Low Frequency		Impulse 1 ½ x 40 MS Wave								
			Test Voltage KV	Max. Micro-volts	Dry	Wet	Pos.	Neg.					Net	Pkd.	
44NP	55-1	4	5	50	35	20	50	70	50	2¼	4	3000	1.30	1.42	50
2NP	55-2	4	5	50	50	25	75	95	70	3⅜	5	2500	1.40	1.52	50
9995NP	55-3	5	10	50	65	35	100	130	90	4½	7	2500	2.25	2.44	27
6510NP	55-4	5	10	50	70	40	110	140	95	5	9	3000	2.90	3.08	12
23514NP	55-5	6	15	100	85	45	140	170	115	6¼	12	3000	5.25	5.67	12
23583NP	–	5	10	50	70	40	110	140	95	5	9	3000	3.5	3.6	18

88NP 115 140

JOINT EEI-NEMA
PIN TYPE
FOR USE


2
1
10
11
3
4
5
8
9
7
6

Cutaway view of Locke High Voltage Multipart Pin Type Insulator

MULTIPART
HIGH VOLTAGE
RADIO NOISE FREED

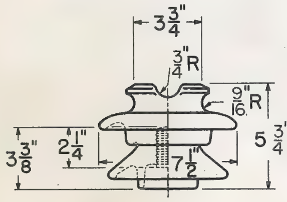
Locke multipart pin type insulators consist of two or more porcelain shells which are assembled to form an integral unit. This type of construction makes them less vulnerable to damage. Even with one shell broken, the multipart insulator can normally withstand the line voltage for considerable time without difficulty.

VALUABLE FEATURES

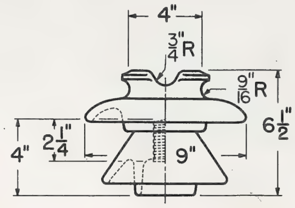
1. The contour of the top conductor groove prevents load concentration on any one point. This feature avoids insulator failure or conductor breakage.

2. The top groove is high above the surface of the top shell to give ample space for easy tying. Danger of reducing valuable insulating surface by contact between top shell and conductor is eliminated. The top wire groove will accommodate conductors as large as 336,400 CM, ACSR with armor rods.

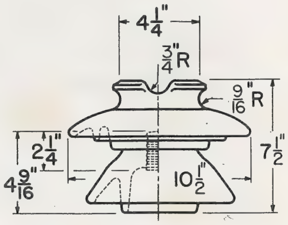
3. The side wire groove, placed high in respect to the conductor groove, permits holding the conductor without sharp bends in either the tie wire or the conductor, avoiding conductor crystallization and costly line failure. It will accommodate 4/0 ACSR with armor rods.


$3\frac{3}{4}$"
$\frac{3}{4}$"R
$\frac{9}{16}$"R
$3\frac{3}{8}$"
$2\frac{1}{4}$"
$7\frac{1}{2}$"
$5\frac{3}{4}$"

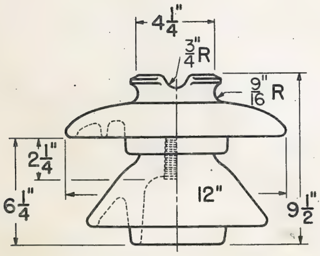
NO. 1027NP


4"
$\frac{3}{4}$"R
$\frac{9}{16}$"R
$6\frac{1}{2}$"
4"
$2\frac{1}{4}$"
9"

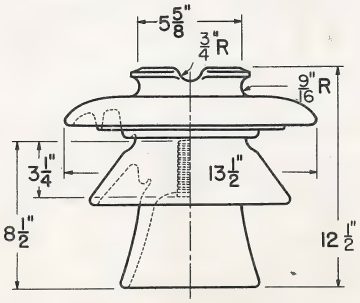
NO. 1035NP


$4\frac{1}{4}$"
$\frac{3}{4}$"R
$\frac{9}{16}$"R
$2\frac{1}{4}$"
$7\frac{1}{2}$"
$4\frac{9}{16}$"
$10\frac{1}{2}$"

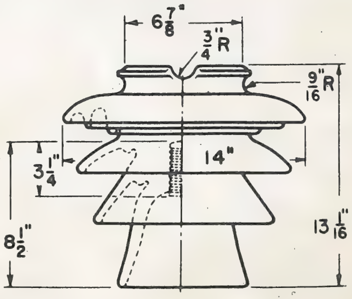
NO. 1044NP


$4\frac{1}{4}$"
$\frac{3}{4}$"R
$\frac{9}{16}$" R
$2\frac{1}{4}$"
$6\frac{1}{4}$"
12"
$9\frac{1}{2}$"

NO. 1055NP


$5\frac{5}{8}$"
$\frac{3}{4}$"R
$\frac{9}{16}$"R
$3\frac{1}{4}$"
$13\frac{1}{2}$"
$8\frac{1}{2}$"
$12\frac{1}{2}$"

NO. 1066NP


$6\frac{7}{8}$"
$\frac{3}{4}$"R
$\frac{9}{16}$"R
$3\frac{1}{4}$"
14"
$8\frac{1}{2}$"
$13\frac{1}{16}$"

NO. 1070NP

NON-STANDARD
FOR SPECIAL APPLICATIONS

STANDARD TDJ-56
INSULATORS
ABOVE 23 KV

4. The large radius of the side wire groove allows the conductor to be placed in this groove for changes in line direction, even when it is protected by armor rods.

5. Design gives maximum flashover value per pound without sacrificing ruggedness or strength.

6. Smooth surfaces offer dirt no hold. Leakage distance is ample and driving rains will clean surface, except under abnormal conditions.

7. Perfect fit of pin threads, within established NEMA standards, permits the insulator to develop its full rated mechanical strength and eliminates corona within the pin hole.

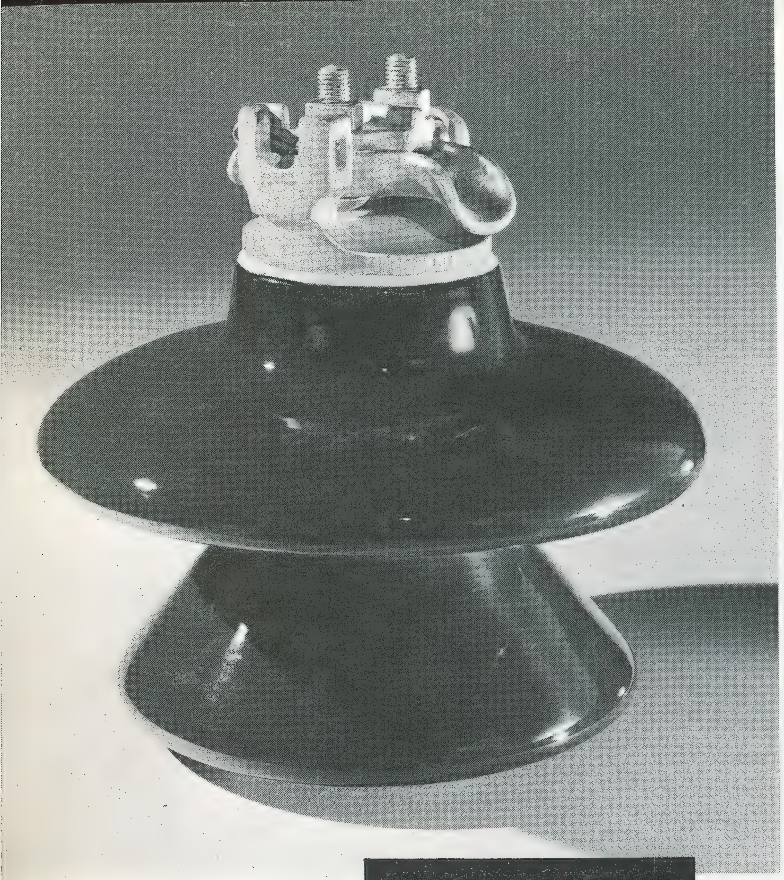
8. The shells are proportioned, as far as practical, for equal voltage distribution between them. This prevents cascading under lightning and assures a puncture value high above the flashover value. It also tends to eliminate corona and gives relative freedom from radio interference.

9. Clearance between shells and particularly between the center shell and pin prevents power leakage sparks. This avoids loss of valuable insulating surfaces, "static" and even occasional flashovers.

10. Shells are scientifically cemented to prevent porcelain damage. Joints are reduced to a minimum width and have a definite taper. This protects the insulator from stresses due to sudden thermal changes. For details on cement joints, see page 12.

11. Locke compression glaze and Metaglaze assure high resistance to thermal shock and mechanical impact while maintaining excellent electrical and radio noise characteristics. Brown glaze is standard. Other colors available on request. For further information on Metaglaze and radio noise freedom, see page 10.

Catalog Number	E. E. I. Class	Radio Influence Voltage at 1000 Kc		Minimum Pin Height Inches	Flashover—Kv				Arcing Distance Inches	Leakage Distance Inches	Cantilever Strength Pounds	Weight Each Pounds		Std. Pkg. Quan.
					Low Frequency		Impulse 1½ x 40 Ms Wave							
		Test Voltage Kv	Max. Microvolts		Dry	Wet	Pos.	Neg.				Net	Pkd.	
1027NP	56-1	15	100	6	95	60	150	190	7	13	2500	7¾	8½	8
1035NP	56-2	22	100	7	110	70	175	225	8¼	17	3000	10¼	11¼	8
1044NP	56-3	30	200	8	125	80	200	265	9½	21	3000	16¾	18	4
1055NP	56-4	30	200	10	140	95	225	310	11¼	27	3000	22	31	3
1066NP	56-5	44	200	12	175	125	270	340	14	34	3000	35	49	3
1070NP	----	44	200	14	180	135	285	360	15¾	41	3000	45	57	3



PIN TYPE

FOR SPECIAL APPLICATIONS

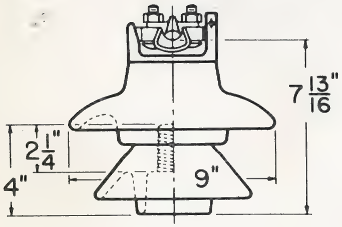
MULTIPART
CLAMP TOP TYPE
RADIO NOISE FREED

Locke Clamp-Top Insulators cannot cause radio interference. The heavy clamp mounting acts as an arcing horn and protects conductors from burning.

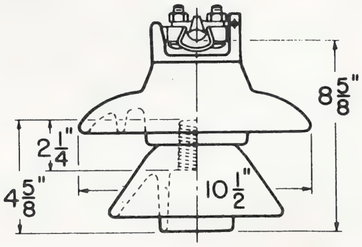
Elimination of tie wires makes conductor easy to install on Locke clamp-top insulators. Each point of support has equally high holding power and dependability. Flexible movement of the clamp eliminates chance of cable abrasion. Use of Locke clamp tops cuts installation time and makes hot line maintenance easier.

No special tools are required either to install or replace an insulator.

In addition, where the conductor size is changed, a replacement clamp may be purchased separately.



NO. 23835 AND 23935



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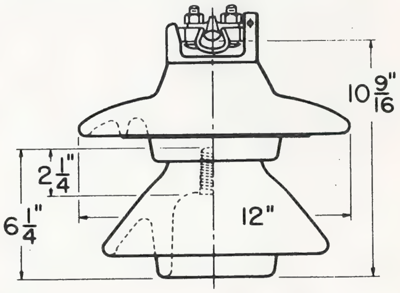

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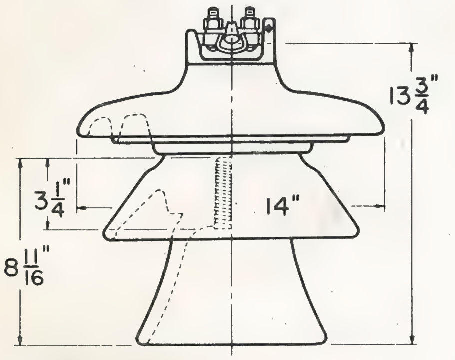
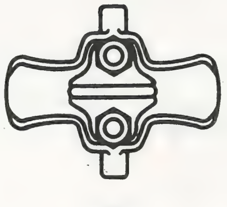
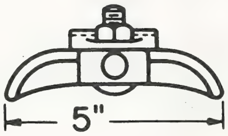


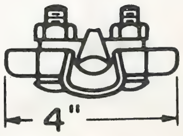
NO. 23866 AND 23966

Clamp **NO. 20341**
For conductors
1/8″ to 3/4″ diameter

Clamp **NO. 20342**
For conductors
1/2″ to 1-1/16″ diameter

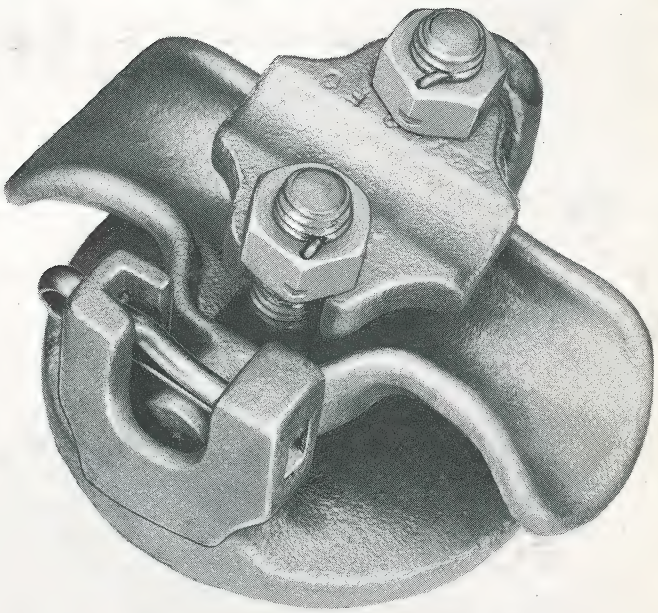






INSULATORS

ABOVE 23 KV.



VALUABLE FEATURES:

1. High trunnion seat permits maximum free clamp movement with conductor vibration.

2. Heavy duty cotter key maintains electrical contact with trunnion at all times. It cannot be completely removed, but is easily withdrawn to permit removal of clamp.

3. Wide, smooth bell mouth eliminates conductor chafing.

4. Reversible keeper accommodates maximum number of conductor sizes, and holds conductor gently and firmly without danger of crystallization.

5. Special lock-nuts prevent loosening of grip in service.

6. Smooth rounded edges retard corona formation.

EASIEST HOT LINE MAINTENANCE

Replacing a Locke Clamp-Top Insulator, even with the line hot, is as simple as the original installation.

1. Pull out the cotter key. Don't be afraid to treat it rough; it can't be pulled completely out.

2. Raise the conductor with the clamp still attached.

3. Install the new insulator—minus the clamp.

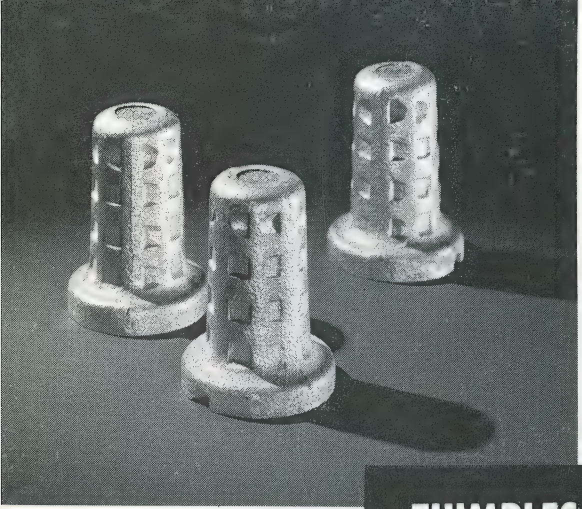
4. Drop the original clamp into place on the new insulator and drive the cotter key home. No waste of time, no special tools, no resagging!

All these insulators have cemented-in metallic thimbles to fit 1⅜″ pin threads. Other pin hole sizes furnished on request.
See Data Table Notes, page 90.

Catalog Number		Radio Influence Voltage at 1000 Kc		Min. Pin Ht., Inches	Flashover—KV				Arcing Distance Inches	Leakage Distance, Inches	Mech. Cant. Stgth. Lbs.	Wt. Each Lbs.		Std. Pkg. Quan.
For Conductor ⅛″-¾″ Dia.	For Conductor ½″-1 1/16″ Dia.	Test Voltage KV	Max. Microvolts		Low Frequency		Impulse 1½ x 40 MS Wave					Net	Pkd.	
					Dry	Wet	Pos.	Neg.						
23835	23935	22	100	7	110	70	175	225	8¼	17	2000	11	12	6
23844	23944	30	200	8	125	80	200	265	9½	21	2000	16	17½	6
23855	23955	30	200	10	140	95	225	310	11¼	27	2000	21¼	23¾	3
23866	23966	44	200	12	175	125	270	340	14	34	2500	35	44	3

These clamp top type insulators can be furnished without clamps (Nos. 23335, 23344, 23355 or 23366).

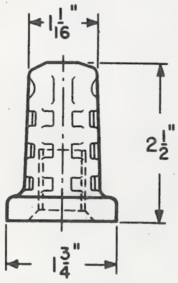
PIN TYPE INSULATORS



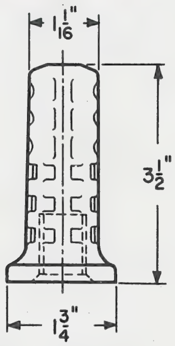
THIMBLES

All Locke high voltage pin type insulators are furnished with 1⅜″ thimbles as standard. The use of this size is preferred from the standpoint of economy and availability.

For replacement, and other applications where such standards cannot be used, and to fit pins of older and obsolete types, Locke offers the thimbles below. They can be permanently cemented into the insulators at the factory.



NO. 9521



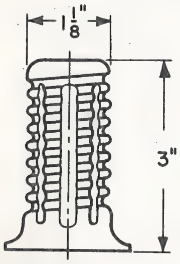
NO. 9522

NO. 9521 Galvanized iron thimble for cementing into insulators. For use with pins with ¾″—N.C. thread such as Nos. 3124 to 3155, Lee and Keystone types, and for insulators with pin hole depth of 2¼ to 2½″ such as Nos. 1027NP, 1035NP, 1044NP and 1055NP.

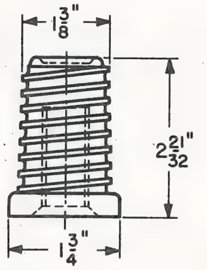
NO. 9522 Same as No. 9521, but for insulators with pin hole depth of 3¼ to 3½″, such as Nos. 1066NP and 1070NP.

THIMBLE ADAPTERS

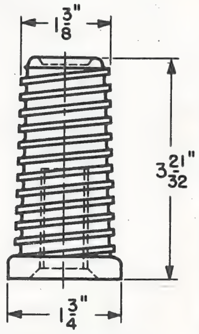
While the use of standard pins and pin holes is preferred for all new construction, economy occasionally dictates use of existing non-standard materials. In these cases, Locke thimble adapters will be of real service.



NO. 4019



NO. 9523



NO. 9524

Catalog Number	Material	For Use With		Lbs. per 100
		Type Pin Head	Type Pin Hole	
4019	Malleable iron, galvanized	¾″-10 thread	1 7/32″ metal thimble	63
9523	Galvanized cast iron with lead threads	¾″-10 thread, 1¾″ deep	Standard 1⅜″	100
9524	Galvanized cast iron with lead threads	¾″-10 thread, 1¾″ deep	Standard 1⅜″ over 2¼″ to 3½″ deep	150

Pages 99-104 reserved for Line Posts

LOW AND MEDIUM VOLTAGE PIN TYPE

1. SCOPE

1.1 These standards cover low- and medium-voltage pin-type insulators made of wet-process porcelain used in the transmission and distribution of electrical energy.

2. DEFINITIONS

2.1 See Section 2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof, for definition of terms (Page 204).

3. GENERAL

3.1 Standard insulators shall conform in all respects to the requirements hereinafter stated. The text, data sheets, and data sheet drawings supplement each other and shall be considered as part of these standards.

3.2 The data sheet drawings are type drawings, and over-all dimensions are shown.

3.3 Manufacturer's drawings, if furnished, shall show the outline of the insulators together with all pertinent dimensions. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

4. MATERIAL

4.1 The insulators shall be made of good commercial grade wet-process porcelain.

4.2 The entire surface of the insulators, with the exception of a firing surface, shall be glazed. The standard color of the glaze shall be brown. The entire surface shall be relatively free from imperfections.

5. DIMENSIONS AND CHARACTERISTICS

5.1 Dimensions and characteristics shall be in accordance with the data sheets.

6. MARKING

6.1 Each insulator shall bear symbols identifying the manufacturer. The marking shall be legible and durable.

7. PACKING

7.1 Insulators shall be so packed as to prevent injury to them during transportation and handling. Insulators packed in containers conforming to all construction requirements of Consolidated Freight classifications as to bursting tests, size limit and gross weight shall be considered as being adequately packed.

7.2 Each box or container shall be marked with the number of pieces contained therein, the catalogue number, or drawing number, or description of the contents, and the manufacturer's name.

8. MANUFACTURER'S PRODUCTION SAMPLING AND TESTS

8.1 The manufacturer shall make adequate tests to determine that insulators manufactured in accordance with these standards will meet the requirements thereof.

9. SAMPLING, INSPECTION AND TESTS

9.1 **General.** Substantial test experience, over a long period of time, indicates that a total of ½ of one per cent of the number of insulators in a lot is sufficient to establish characteristics demonstrable by destructive tests.

9.2 **Dimensions.** Three insulators shall be selected at random from the lot and their dimensions checked against the dimensions on the manufacturer's drawing. Failure of more than one of these insulators to conform, within manufacturing tolerances, to the dimensions on this drawing shall constitute failure of the lot to meet this standard.

9.3 **Design Tests.** Certified test data on insulators of existing design shall be regarded as equivalent to actual design tests. Design tests on insulators of new design shall be made in accordance with paragraphs 9.3.1 through 9.3.4.

9.3.1 **Low-frequency Dry-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.1 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average dry-flashover value of the three insulators to equal or exceed 95 per cent of the rated dry-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.2 **Low-frequency Wet-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average wet-flashover value of the three insulators to equal or exceed 90 per cent of the rated wet-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.3 **Critical-impulse Flashover—Positive and Negative.** Three insulators shall be selected at random for the critical-impulse flashover, positive, and three for the critical-impulse flashover, negative, and tested in accordance with Section 4.3 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average critical-impulse flashover value of the three insulators to equal or exceed 92 per cent of the rated critical-impulse flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.4 **Radio-influence Voltage.** Five insulators shall be selected at random and tested in accordance with Section 4.5 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. If one or more insulators fail to meet the requirements given on the applicable data sheet, five additional insulators shall be selected at random and tested. Failure of one or more of these additional insulators shall constitute failure to meet this standard.

9.4 **Quality Control Tests**

9.4.1 **Visual.** If visual inspection is required on lots of 500 or more insulators, 50 insulators shall be selected at random from the lot. If more than 4 but less than 10 of the insulators fail to meet the requirements of paragraph 4.2, 100 additional insulators shall be selected at random from the same lot. Failure of more than 10 insulators total from both the first and second samples shall constitute failure of the lot to meet this standard.

9.4.2 **Porosity.** Test specimens shall be selected from insulators destroyed in other tests and tested in accordance with Section 5.4 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Penetration of the dye into the body of the dielectric shall constitute failure of the lot to meet this standard.

9.4.3 **Routine Flashover.** Each insulator shall be subjected to a routine flashover test in accordance with paragraph 7.1.1 or 7.1.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. All insulators which puncture fail to meet this standard.

9.4.4 **Thermal Shock.** Five insulators shall be selected at random and tested in accordance with Section 5.5 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. If one or more insulators fail, five additional insulators shall be selected at random from the same lot and tested. Failure of one or more of these additional insulators shall constitute failure of the lot to meet this standard.

9.4.5 **Cantilever Strength.** Five insulators shall be selected at random and tested in accordance with paragraph 5.1.3 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof.

LOW AND MEDIUM VOLTAGE PIN TYPE (CONT.)

Failure of the average strength of the five insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85 per cent of that strength requirement shall constitute failure of the lot to meet this standard.

9.4.6 Pin-hole Gaging. From the insulators used for visual inspection, 15 insulators shall be selected at random and gaged with a gage similar to that shown in Figure 5 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. The clearance between the top of the gage and the crown of the pin-hole cavity shall not be less than ⅛ inch nor more than ¾ inch. The number of turns to disengage the insulator from the gage shall average not less than 3 for the entire sample nor be less than 2¼ for any one insulator. If more than one insulator fails to meet this requirement, 30 additional insulators shall be selected at random and gaged. Failure of more than three insulators total from both the first and second samples shall constitute failure of the lot to meet this standard.

9.4.7 Puncture Test. Five insulators shall be selected at random and tested in accordance with Section 4.7 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. The oil used in this test shall have a breakdown voltage of not less than 12.5 Kv when measured in accordance with paragraphs 22, 23 and 24 of *ASTM Methods of Testing Electrical Insulating Oils,** Publication No. D 117-50, or latest revision thereof. If the average puncture voltage of the five insulators fails to meet the requirement given on the applicable data sheet or if the per cent average variation exceeds ten, this shall constitute failure of the lot to meet this standard.

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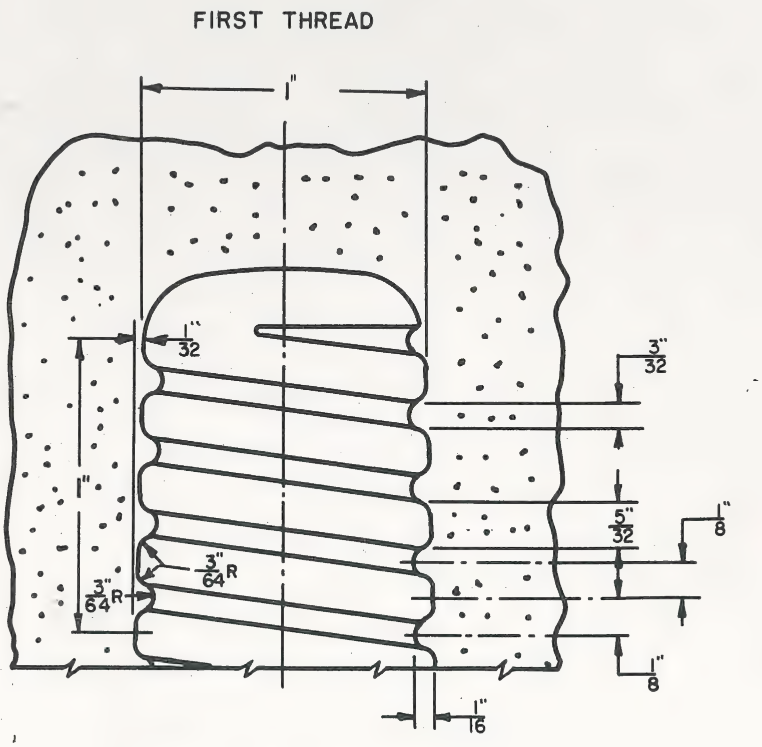


Pin-hole Thread Dimensions

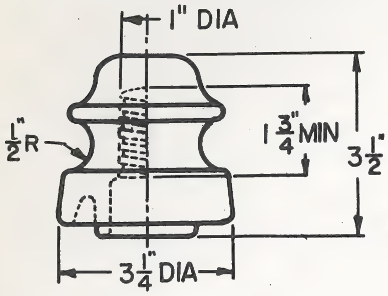
FIG. A

NOTE I—Thread fit to be checked with the insulator thread gage shown in Figure 5 of the *American Standard Insulator Tests,* Publication No. C29.1-1944 (1.000-inch size).

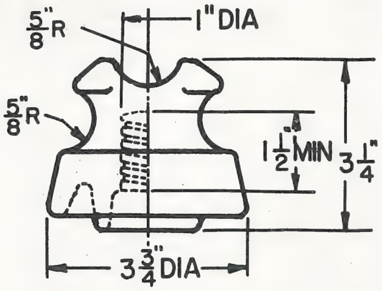
NOTE II—Threads—4 threads per inch, tapering 1/16 inch in diameter to 1 inch in length.

STANDARDS

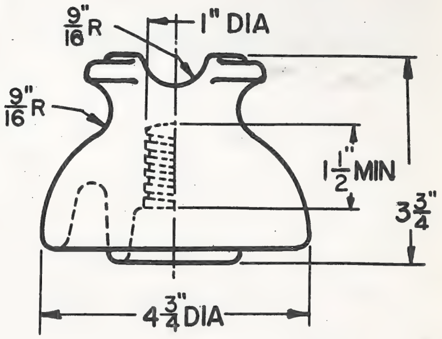
FOR WET PROCESS PORCELAIN INSULATORS



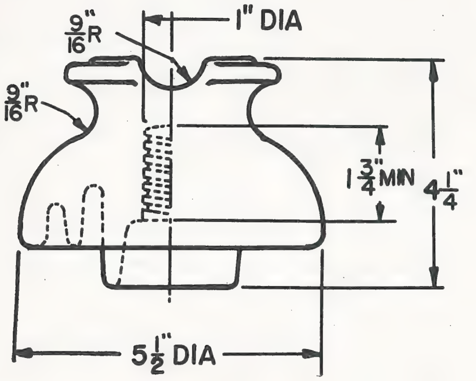
Class 55-1*



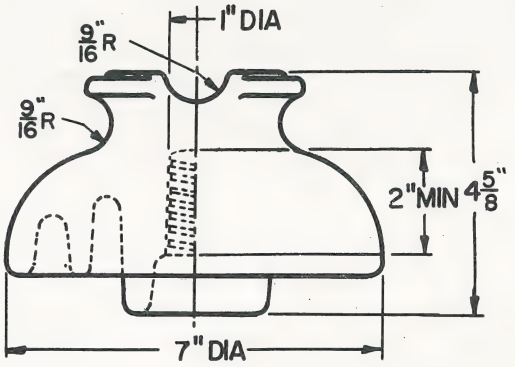
Class 55-2†



Class 55-3‡



Class 55-4‡



Class 55-5‡

Characteristics	Class 55-1	Class 55-2	Class 55-3	Class 55-4	Class 55-5	Paragraph In Pub. No. C29.1-1944
1. DIMENSIONS						
a. Leakage Distance, Inches	4	5	7	9	12	2.6.1
b. Dry Arcing Distance, Inches	2¼	3⅜	4½	5	6¼	2.6.2
c. Minimum Pin Height, Inches	4	4	5	5	6	——
2. MECHANICAL VALUES						
a. Cantilever Strength, Pounds	3000	2500	2500	3000	3000	5.1.3
3. ELECTRICAL VALUES						
a. Low-frequency Dry Flashover, Kv	35	50	65	70	85	4.1
b. Low-frequency Wet Flashover, Kv	20	25	35	40	45	4.2
c. Impulse Flashover—Positive, Kv	50	75	100	110	140	4.3
d. Impulse Flashover—Negative, Kv	70	95	130	140	170	4.3
e. Low-frequency Puncture Voltage, Kv	50	70	90	95	115	4.7
4. RADIO INFLUENCE VOLTAGE DATA						
a. Low-frequency Test Voltage—Rms to Ground, Kv	5	5	10	10	15	4.5
b. Maximum Radio Influence Voltage—Microvolts at 1000 Kilocycles Radio Freed	50	50	50	50	100	4.5
Plain	2500	2500	5500	5500	8000	4.5

*Side wire groove shall seat a 15/16-inch diameter mandrel.
†Top and side wire grooves shall seat a 1-3/16-inch diameter mandrel.
‡Top and side wire grooves shall seat a 1-1/16-inch diameter mandrel.
NOTE I—If high resistance coatings are applied to the insulator, such coatings shall be considered as effective leakage surfaces, and distance over them shall be included in the leakage distance.
NOTE II—Pinhole thread dimensions shall be in accordance with Figure A, page 106

HIGH VOLTAGE PIN TYPE

1. SCOPE

1.1 These standards cover high-voltage pin-type insulators made of wet-process porcelain used in the transmission and distribution of electrical energy.

2. DEFINITIONS

2.1 See Section 2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof, for definition of terms (Page 204).

3. GENERAL

3.1 Standard insulators shall conform in all respects to the requirements hereinafter stated. The text, data sheets, and data sheet drawings supplement each other and shall be considered as parts of these standards.

3.2 The data sheet drawings are type drawings, and overall dimensions are shown.

3.3 Manufacturer's drawings, if furnished, shall show the outline of the insulators together with all pertinent dimensions. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

4. MATERIAL

4.1 The insulators shall be made of a good commercial grade wet-process porcelain.

4.2 The entire porcelain surface of the insulators, with the exception of a firing surface, shall be glazed. The standard color of the glaze shall be brown. The entire porcelain surface shall be relatively free from imperfections.

4.3 Ferrous metal parts shall be made of a good commercial grade of malleable iron or open hearth or electric furnace steel, galvanized in accordance with *ASTM Specifications for Zinc Coating (Hot-Dip) on Iron and Steel Hardware,** Publication No. A 153-49, or latest revision thereof. Other metal parts shall be made of a material of suitable corrosion resistance and temper.

*Copies are available from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

5. DIMENSIONS AND CHARACTERISTICS

5.1 Dimensions and characteristics shall be in accordance with the data sheets.

6. MARKING

6.1 Each insulator shall bear symbols identifying the manufacturer and the year of manufacture. The marking shall be legible and durable.

7. PACKING

7.1 Insulators shall be so packed as to prevent injury to them during transportation and handling. Insulators packed in containers conforming to all construction requirements of Consolidated Freight classifications as to bursting tests, size limit and gross weight shall be considered as being adequately packed.

7.2 Each box or container shall be marked with the number of pieces contained therein, the catalog number, or drawing number, or description of the contents, and the manufacturer's name.

8. MANUFACTURER'S PRODUCTION SAMPLING AND TESTS

8.1 The manufacturer shall make adequate tests to determine that insulators manufactured in accordance with these standards will meet the requirements thereof.

9. SAMPLING, INSPECTION AND TESTS

9.1 **General.** Substantial test experience, over a long period of time, indicates that a total of ½ of one per cent of the number of insulators in a lot is sufficient to establish characteristics demonstrable by destructive tests.

9.2 **Dimensions.** Three insulators shall be selected at random from the lot and their dimensions checked against the dimensions on the manufacturer's drawing. Failure of more than one of these insulators to conform, within manufacturing tolerances, to the dimensions on this drawing shall constitute failure of the lot to meet this standard.

9.3 **Design Tests.** Certified test data on insulators of existing design shall be regarded as equivalent to actual design tests. Design tests on insulators of new design shall be made in accordance with paragraphs 9.3.1 through 9.3.4.

9.3.1 **Low-frequency Dry-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.1 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average dry-flashover value of the three insulators to equal or exceed 95 per cent of the rated dry-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.2 **Low-frequency Wet-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average wet-flashover value of the three insulators to equal or exceed 90 per cent of the rated wet-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.3 **Critical-impulse Flashover—Positive and Negative.** Three insulators shall be selected at random for the critical-impulse flashover, positive, and three for the critical-impulse flashover, negative, and tested in accordance with Section 4.3 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average critical-impulse flashover value of the three insulators to equal or exceed 92 per cent of the rated critical-impulse flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.4 **Radio-influence Voltage.** Five insulators shall be selected at random and tested in accordance with Section 4.5 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. If one or more insulators fail to meet the requirements given on the applicable data sheet, five additional insulators shall be selected at random and tested. Failure of one or more of these additional insulators shall constitute failure to meet this standard.

9.4 **Quality Control Tests**

9.4.1 **Visual.** Conformity with paragraph 4.2 may be determined by visual inspection. All insulators not conforming to paragraph 4.2 fail to meet this standard.

9.4.2 **Porosity.** Test specimens shall be selected from insulators destroyed in other tests and tested in accordance with Section 5.4 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Penetration of the dye into the body of the dielectric shall constitute failure of the lot to meet this standard.

9.4.3 **Galvanizing.** Five pieces representative of each type of hardware used with the insulators shall be selected at random before assembly and tested in accordance with Section 6.1 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of more than one specimen to withstand six one-minute copper sulphate dips [see *ASTM Method of Test for Uniformity of Coating by the Preece Test (Copper Sulphate Dip) on Zinc-coated (Galvanized) Iron or Steel Articles,* Publication No. A 239-41] shall constitute failure to meet this standard.

9.4.4 **Routine Flashover.** Each insulator shall be subjected to a routine flashover test in accordance with paragraph 7.1.1 or 7.1.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. All insulators which puncture fail to meet this standard.

9.4.5 **Thermal Shock.** Five insulators shall be selected at random and tested in accordance with Section 5.5 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. If one or more insulators fail, five additional insulators shall be selected at random from the same lot and tested. Failure of one or more of these additional insulators shall constitute failure of the lot to meet this standard.

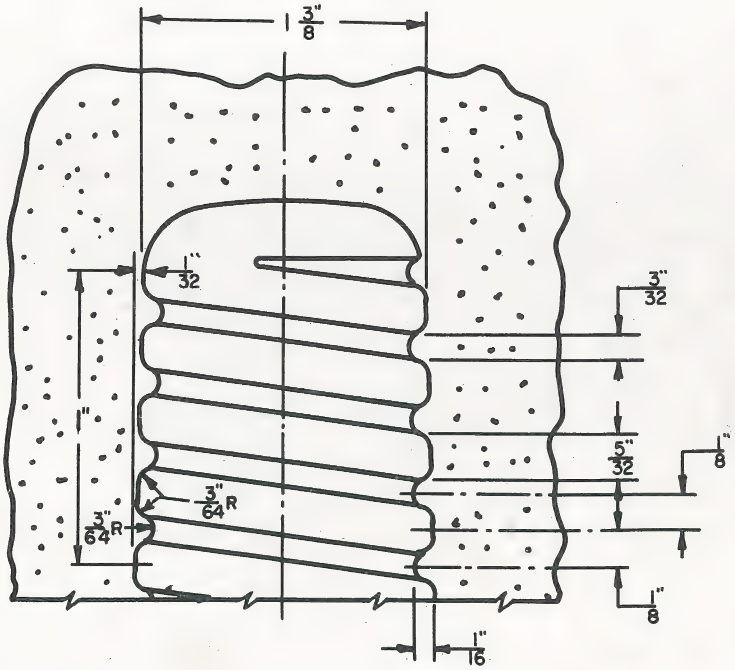
9.4.6 **Cantilever Strength.** Three insulators shall be selected at random and tested in accordance with paragraph 5.1.3 of the *American Standard Insulator Tests*, Publication No. C29.1-1944, or latest revision thereof. Failure of the average strength of the three insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85 per cent of that strength requirement shall constitute failure of the lot to meet this standard.

9.4.7 **Pin-hole Gaging (Metal Shell Thimbles).** Fifteen insulators shall be selected at random from each lot and gaged with a gage similar to that shown in Figure 5 of the *American Standard Insulator Tests*, Publication No. C29.1-1944, or latest revision thereof. The clearance between the top of the gage and the crown of the pin-hole cavity shall not be less than ⅛ inch or more than ¾ inch. The number of turns to disengage the insulator from the gage shall average not less than 3½ for the entire sample nor be less than 3 for any one insulator. If more than one insulator fails to meet this requirement, 30 additional insulators shall be selected at random and gaged. Failure of more than three insulators total from both the first and second samples shall constitute failure of the lot to meet this standard.

9.4.8 **Pin-hole Gaging (Porcelain Threads).** Fifteen insulators shall be selected at random from each lot and gaged with a gage similar to that shown in Figure 5 of the *American Standard Insulator Tests*, Publication No. C29.1-1944, or latest revision thereof. The clearance between the top of the gage and the crown of the pin-hole cavity shall not be less than ⅛ inch or more than ¾ inch. The number of turns to disengage the insulator from the gage shall average not less than 3 for the entire sample nor be less than 2¼ for any one insulator. If more than one insulator fails to meet this requirement, 30 additional insulators shall be selected at random and gaged. Failure of more than three insulators total from both the first and second samples shall constitute failure of the lot to meet this standard.

9.4.9 **Puncture Tests.** Three assembled insulators shall be selected at random and tested in accordance with Section 4.7 of the *American Standard Insulator Tests*, Publication No. C29.1-1944, or latest revision thereof. The oil used in this test shall have a breakdown voltage of not less than 12.5 Kv when measured in accordance with paragraphs 22, 23 and 24 of the *ASTM Methods of Testing Electrical Insulating Oils*, Publication No. D 117-50, or latest revision thereof. If the average puncture voltage of the three insulators fails to meet the requirement given on the applicable data sheet or if the per cent average variation exceeds fifteen, this shall constitute failure of the lot to meet this standard.

FIRST THREAD



Pin-hole Thread Dimensions

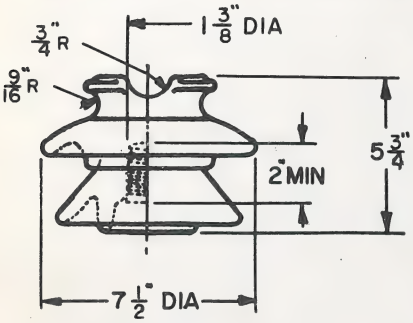
FIG. A

NOTE I—Thread fit to be checked with the insulator thread gage shown in Figure 5 of the *American Standard Insulator Tests*, Publication No. C29.1-1944 (1.375-inch size).

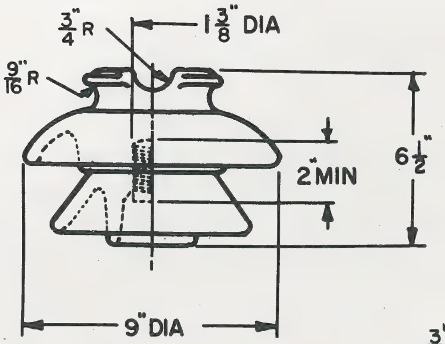
NOTE II—Threads—4 threads per inch, tapering 1/16 inch in diameter to 1 inch in length.

EEI-NEMA STANDARDS

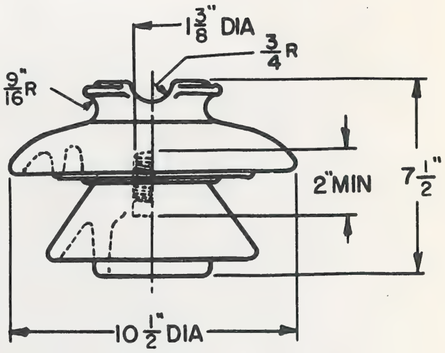
HIGH VOLTAGE PIN TYPE (CONT.)


1 3/8" DIA
3/4" R
9/16" R
2" MIN
5 3/4"
7 1/2" DIA

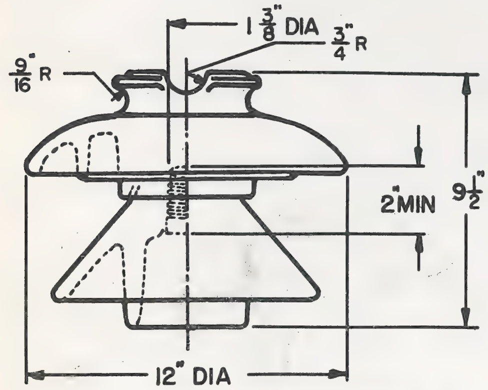
Class 56-1


3/4" R
1 3/8" DIA
9/16" R
2" MIN
6 1/2"
9" DIA

Class 56-2

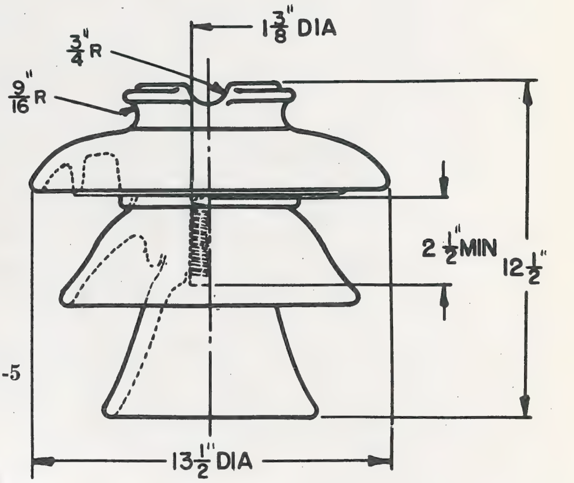

1 3/8" DIA
3/4 R
9/16" R
2" MIN
7 1/2"
10 1/2" DIA

Class 56-3


1 3/8" DIA
3/4" R
9/16" R
2" MIN
9 1/2"
12" DIA

Class 56-4

Class 56-5

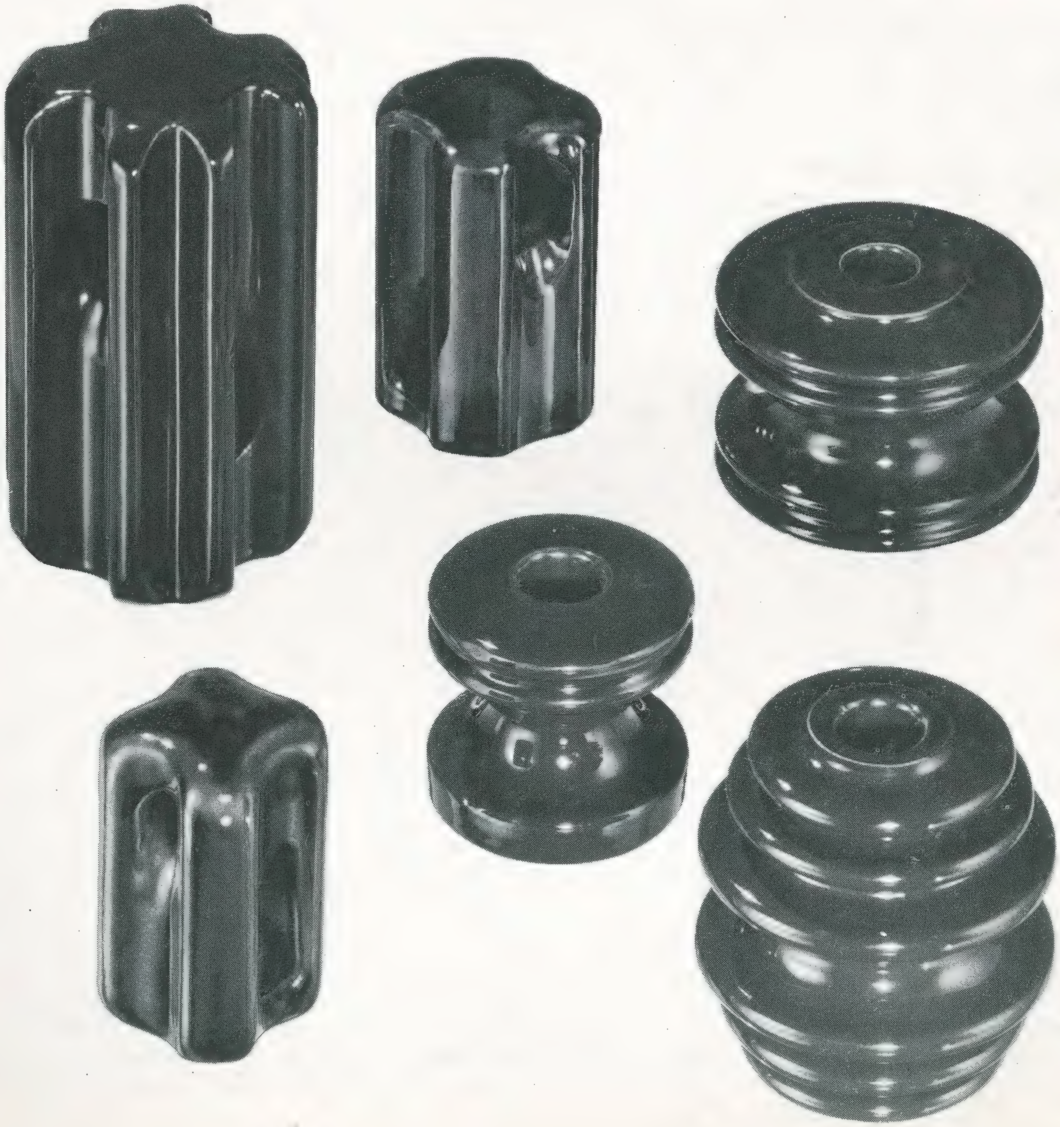

1 3/8" DIA
3/4" R
9/16" R
2 1/2" MIN
12 1/2"
13 1/2" DIA

Characteristics	Class 56-1	Class 56-2	Class 56-3	Class 56-4	Class 56-5	Paragraph In Pub. No. C29.1-1944
1. DIMENSIONS						
a. Leakage Distance, Inches	13	17	21	27	34	2.6.1
b. Dry Arcing Distance, Inches	7	8¼	9½	11¼	14	2.6.2
c. Minimum Pin Height, Inches	6	7	8	10	12	—
2. MECHANICAL VALUES						
a. Cantilever Strength, Pounds	2500	3000	3000	3000	3000	5.1.3
3. ELECTRICAL VALUES						
a. Low-frequency Dry Flashover, Kv	95	110	125	140	175	4.1
b. Low-frequency Wet Flashover, Kv	60	70	80	95	125	4.2
c. Impulse Flashover—Positive, Kv	150	175	200	225	270	4.3
d. Impulse Flashover—Negative, Kv	190	225	265	310	340	4.3
e. Low-frequency Puncture Voltage, Kv	130	145	165	185	225	4.7
4. RADIO INFLUENCE VOLTAGE DATA						
a. Low-frequency Test Voltage—Rms to Ground, Kv	15	22	30	30	44	4.5
b. Maximum Radio Influence Voltage—Microvolts						
at 1000 Kilocycles Radio Freed	100	100	200	200	200	4.5
Plain	8000	12000	16000	16000	25000	4.5

NOTE I—If high resistance coatings are applied to the insulator, such coatings shall be considered as effective leakage surfaces, and distance over them shall be included in the leakage distance.
NOTE II—Top wire groove shall seat a 1-7/16-inch diameter mandrel.
NOTE III—Side wire groove shall seat a 1-1/16-inch diameter mandrel.
NOTE IV—Pinhole thread dimensions shall be in accordance with Figure A, page 109.

SPOOL AND GUY INSULATORS

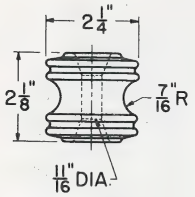
Locke spool and guy insulators are made of finest electrical porcelain, compression glazed for highest strength. They are used for a wide range of low voltage applications. Spools are generally used with service racks or clevises, on secondary circuits. Larger units are also used for dead ending distribution conductors up to 5,000 volts. Guy insulators are used to insulate guy cables which support poles or structures. They are not normally connected in transmission or distribution circuits and may become energized only under emergency conditions, if a broken conductor falls across a portion of the guy. Both spool and guy insulators are so designed that, in use, the load is supported by compression of the porcelain dielectric. This adds greatly to their strength while maintaining required insulation with extreme compactness and a minimum of weight.



SPOOLS
JOINT EEI-NEMA STANDARD TDJ 53

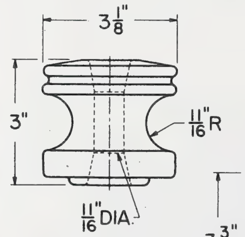
Spools conform to EEI-NEMA Standards and are uniformly glazed a distinctive brown color as standard. For marking and identification of circuits, white glazed spools are available upon request.

2-INCH

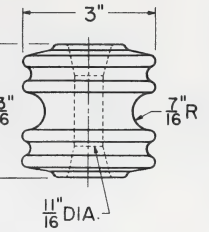

2 1/4"
2 1/8"
7/16"R
11/16"DIA.

NO. 0608

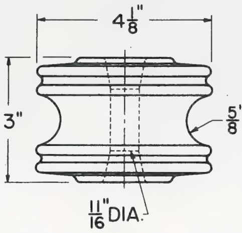
3-INCH


3 1/8"
3"
11/16"R
11/16"DIA.

NO. 355

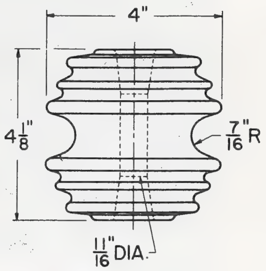

3"
3 3/16"
7/16"R
11/16"DIA.

NO. 0609


4 1/8"
3"
5/8"R
11/16"DIA.

NO. 0716

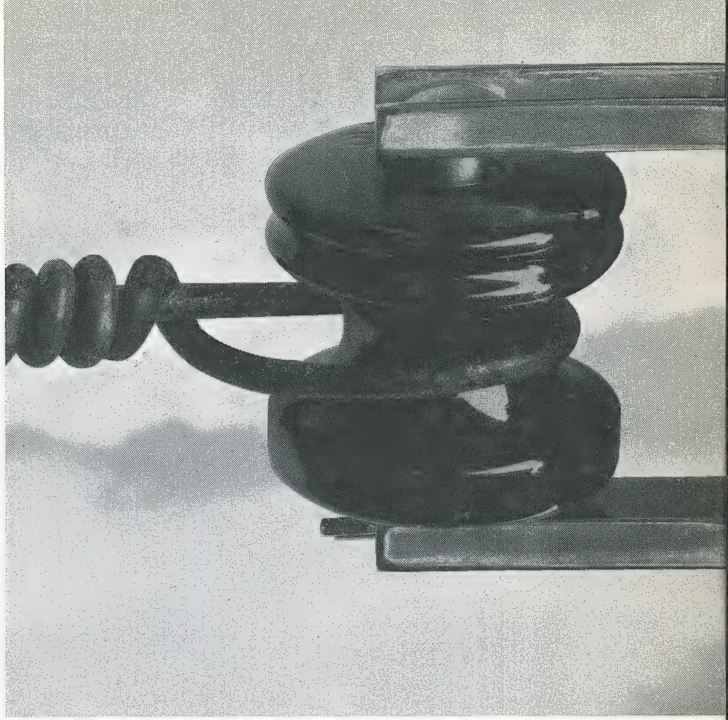
4-INCH


4"
4 1/8"
7/16"R
11/16"DIA.

NO. 0613

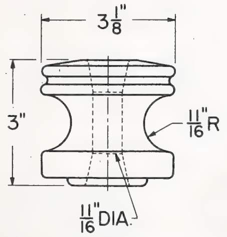
Catalog Number	EEI Class No.	Transverse Strength Lbs.	Flashover—KV			Lbs. per C		Std. Pkg. Quan.	Principal Use
			Dry	Wet					
				Horiz.	Vert.	Net	Pkd.		
0608	53-1	2000	20	10	8	50	54	100	Used principally for secondary drops from pole to building. Seldom used on circuits rated over 600 V.
355	53-2	3000	25	15	12	120	126	50	For secondary circuits as tangent supports and dead-ends. Also as dead-ends on primary distribution circuits up to 4 KV.
0609	53-3	4000	25	15	12	143	150	50	
0716	53-4	4500	25	15	12	258	267	24	
0613	53-5	6000	35	25	18	283	300	24	As dead-ends on primary distribution circuits up to 6.9 KV.

INSULATORS



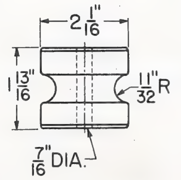
SPOOLS FOR SPECIAL APPLICATIONS

Locke spools for special application are made of dry-process porcelain, except No. 0612. They are compression glazed for increased strength. For applications, see table below.



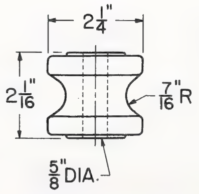
3 1/8"
3"
11/16" R
11/16" DIA.

NO. 255



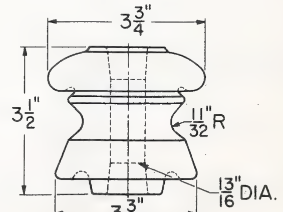
2 1/16"
1 13/16"
11/32" R
7/16" DIA.

NO. 257



2 1/4"
2 1/16"
7/16" R
5/8" DIA.

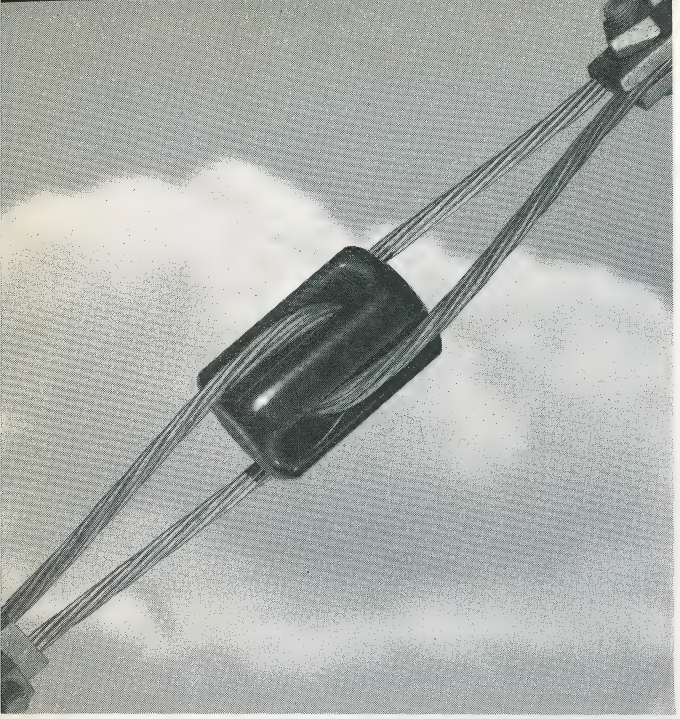
NO. 0606



3 3/4"
3 1/2"
11/32" R
13/16" DIA.
3 3/8"

NO. 0612
WET-PROCESS PORCELAIN

Catalog Number	Lbs. per C		Standard Package	Principal Use
	Net	Pkd.		
255	120	126	50	For secondary supports, as tangent supports and dead-ends.
257	40	44	100	With fork bolts and clevis for low voltage circuits, specially for indoor use in industrial plants.
0606	40	44	100	For secondary drops from pole to building, seldom on circuits rated over 600 V.
0612	180	187	50	For primary and railway signal circuit dead-ends.

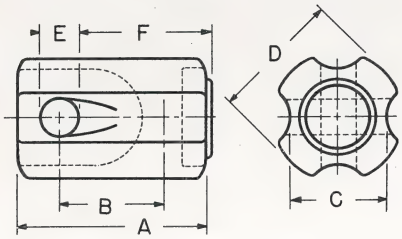


GUY

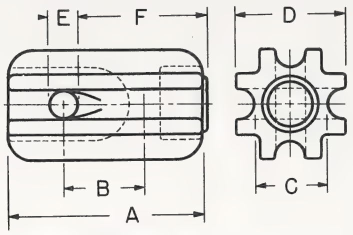
Locke guy strain insulators, made of brown compression glazed wet process porcelain, provide highest quality insulation for low voltage circuits. Rugged strength gives relative freedom from breakage due to impact or rough handling. They have low flashover values and relatively short leakage distances, yet provide required insulation with minimum size and weight. Maximum strength is obtained from porcelain by interlocking the guy cables so that the load places the porcelain between the holes in compression. Cable grooves are rounded and smooth to minimize strand stresses. Guy strain insulators give protection in the event a broken conductor accidentally energizes a guy wire. They may also be used for dead-ends on low voltage circuits.

A and D are maximum average design dimensions. Individual units may exceed these values by 3%. Dimensions C and E have a tolerance of plus or minus 1/16″. F is shown as maximum.

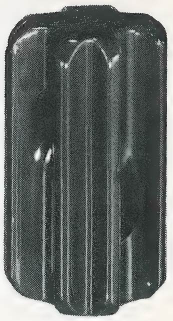
CLOSED END
JOINT EEI-NEMA
STANDARD TDJ 54



NOS. 502 TO 506



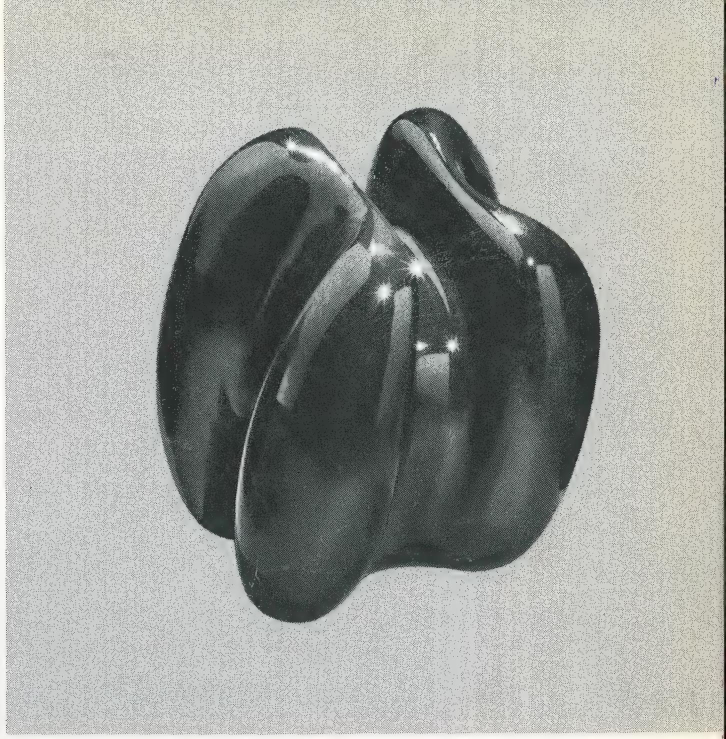
NOS. 7665 AND 7666



Catalog Number	EEI Class No.	*Dimensions—Inches						Mech. Strength Lbs.	Flashover—KV		Leakage Distance Inches	Max. Cable Diam. Inches	Lbs. per C		Std. Pkg. Quan.
		A	B	C	D	E	F		Dry	Wet			Net	Pkd.	
502	54-1	3½	1¾±⅛	1¾	2½	⅝	2½	10000	25	12	1⅝	⅜	100	108	50
504	54-2	4¼	2¼±⅛	2⅛	2⅞	⅞	3	12000	30	15	1⅞	½	164	178	50
506	54-3	5½	3⅛±¼	2⅜	3⅜	1	4¹⁄₁₆	20000	35	18	2¼	⅝	263	316	25
7666	54-4	6¾	2⅝±¼	2⅜	3½	1	4½	20000	40	23	3	⅝	413	444	16
****7665**	Non-Std.	5¾	2⅜±⅛	2⅛	3¼	⅞	3¹³⁄₁₆	12000	30	15	2⁹⁄₁₆	½	250	288	25

* See notes above.
** For special applications.

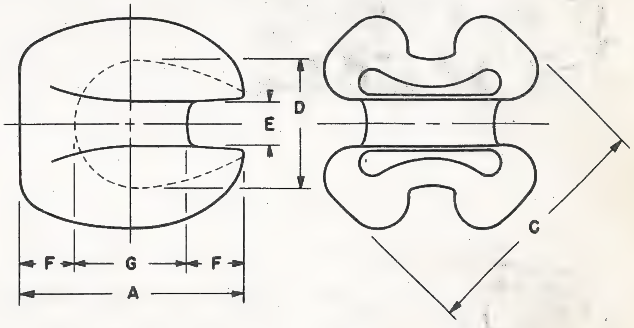
INSULATORS



OPEN END TYPE

For installations where unusually high strength is required, Locke open-end guy insulators are recommended. In addition to their other uses, they are extensively used in radio tower guys and in marine radio work. These insulators are generally used with strand having pre-formed interlocking loops. They are inserted into the guys after erection. Their high mechanical strength and ease of installation makes them highly desirable for special applications beyond the strength range of standard guy insulators.

Locke open end guy insulators are made of brown, compression glazed wet-process porcelain only and conform to U. S. Navy specification 16-I-2-D.



Catalog Number	Cable Size Inches	Dimensions—Inches						Mechanical Strength Lbs.	Flashover—KV		Lbs. per C		Std. Pkg.
		A	C	D	E	F	G		Dry	Wet	Net	Pkd.	
24273	1/4	3	3 3/16	1 1/2	3/8	5/8	1 3/4	12,000	16	7.5	110	122	32
24272	3/8	3 5/16	3 9/16	1 3/4	9/16	3/4	1 13/16	15,000	15	8	150	162	50
24210	1/2	3 3/4	4 1/8	2 1/16	11/16	29/32	1 15/16	20,000	16	8	200	215	32
24212	5/8	4 5/16	4 11/16	2 7/16	7/8	1 3/32	2 1/8	30,000	18	9	300	325	18
24369	3/4	4 5/8	5 5/16	2 13/16	1 1/16	1 3/16	2 1/4	42,000	21	10.5	435	485	12
24213	7/8	5 1/2	6 7/16	3 1/2	1 5/16	1 13/32	2 11/16	57,000	25	13	700	775	8
24221	1	6	7 3/8	4	1 1/2	1 1/2	3	78,000	30	15	1020	1195	8

SPOOL TYPE

1. SCOPE

1.1 These standards cover spool-type insulators made of wet-process porcelain used in the transmission and distribution of electrical energy.

2. DEFINITIONS

2.1 See Section 2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof, for definition of terms.

(Page 204).

3. GENERAL

3.1 Standard insulators shall conform in all respects to the requirements hereinafter stated. The text, data sheets, and data sheet drawings supplement each other and shall be considered as parts of these standards.

3.2 The data sheet drawings are type drawings, and overall dimensions are shown.

3.3 Manufacturer's drawings, if furnished, shall show the outline of the insulators together with all pertinent dimensions. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

4. MATERIAL

4.1 The insulators shall be made of good commercial grade wet-process porcelain.

4.2 The entire surface of the insulator, with the exception of a firing surface, shall be glazed. The standard color of the glaze shall be brown. The entire surface shall be relatively free from imperfections.

5. DIMENSIONS AND CHARACTERISTICS

5.1 Dimensions and characteristics shall be in accordance with the data sheets.

6. MARKING

6.1 Each insulator shall bear a symbol identifying the manufacturer. The marking shall be legible and durable.

7. PACKING

7.1 Insulators shall be so packed as to prevent injury to them during transportation and handling. Insulators packed in containers conforming to all construction requirements of Consolidated Freight classifications as to bursting tests, size limit and gross weight shall be considered as being adequately packed.

7.2 Each box or container shall be marked with the number of pieces contained therein, the catalog number, or drawing number, or description of the contents, and the manufacturer's name.

8. MANUFACTURER'S PRODUCTION SAMPLING AND TESTS

8.1 The manufacturer shall make adequate tests to determine that insulators manufactured in accordance with these standards will meet the requirements thereof.

9. SAMPLING, INSPECTION AND TESTS

9.1 **General.** Substantial test experience, over a long period of time, indicates that a total of ½ of one per cent of the number of insulators in a lot is sufficient to establish characteristics demonstrable by destructive tests.

9.2 **Dimensions.** Three insulators shall be selected at random from the lot and their dimensions checked against the dimensions on the manufacturer's drawing. Failure of more than one of these insulators to conform, within manufacturing tolerances to the dimensions on this drawing shall constitute failure of the lot to meet this standard.

9.3 **Design Tests.** Certified test data on insulators of existing design shall be regarded as equivalent to actual design tests. Design tests on insulators of new design shall be made in accordance with paragraphs 9.3.1 and 9.3.2.

9.3.1 **Low-frequency Dry-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.1 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average dry-flashover value of the three insulators to equal or exceed 95 per cent of the rated dry-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.2 **Low-frequency Wet-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average wet-flashover value of the three insulators to equal or exceed 90 per cent of the rated wet-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.4 Quality Control Tests

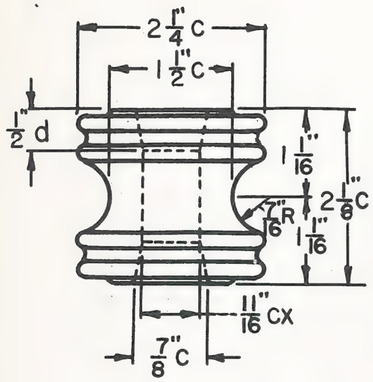
9.4.1 **Visual.** If visual inspection is required on lots of 500 or more insulators, 50 insulators shall be selected at random from the lot. If more than 4 but less than 10 of the insulators fail to meet the requirements of paragraph 4.2, 100 additional insulators shall be selected at random from the same lot. Failure of more than 10 insulators total from both the first and second samples shall constitute failure of the lot to meet this standard.

9.4.2 **Porosity.** Test specimens shall be selected from insulators destroyed in other tests and tested in accordance with Section 5.4 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Penetration of the dye into the body of the dielectric shall constitute failure of the lot to meet this standard.

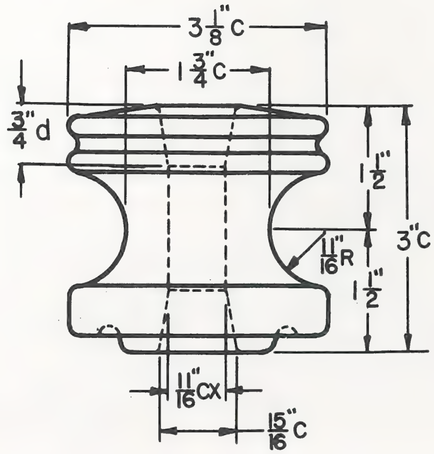
9.4.3 **Transverse Strength.** Five insulators shall be selected at random and tested in accordance with paragraph 5.1.6 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average strength of the five insulators to meet the strength requirements given on the applicable data sheet or failure of any one insulator to equal 85 per cent of that strength requirement shall constitute failure of the lot to meet this standard.

STANDARDS

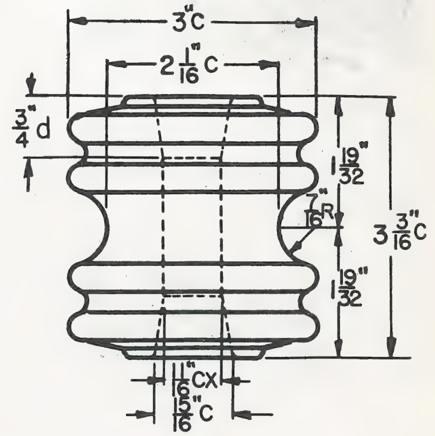
FOR WET PROCESS PORCELAIN INSULATORS


2 1/4" C
1 1/2" C
1/2" d
1 1/16"
2 1/8" C
7/16" R
1 1/16"
11/16" CX
7/8" C

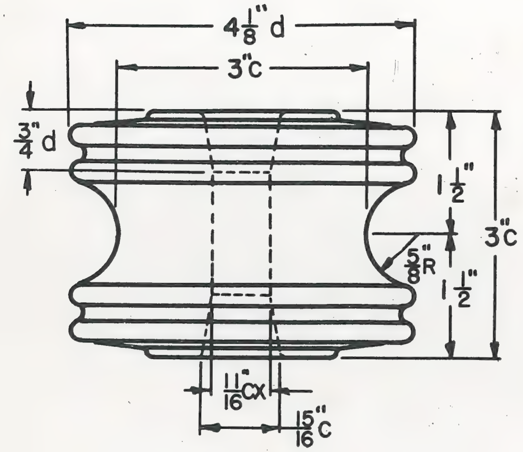
Class 53-1*


3 1/8" C
1 3/4" C
3/4" d
1 1/2"
3" C
11/16" R
1 1/2"
11/16" CX
15/16" C

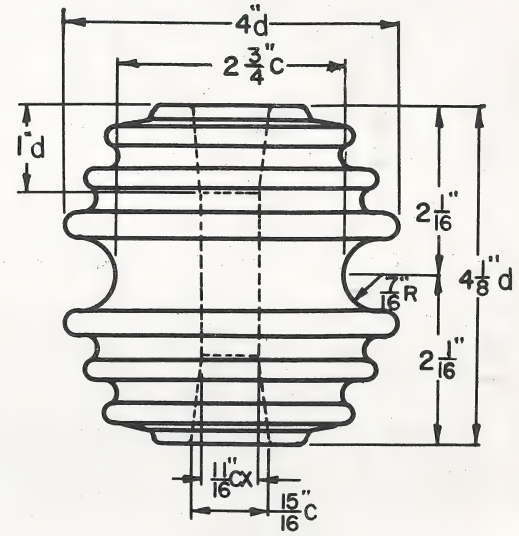
Class 53-2†


3" C
2 1/16" C
3/4" d
1 19/32"
7/16" R
3 3/16" C
1 19/32"
11/16" CX
15/16" C

Class 53-3*


4 1/8" d
3" C
3/4" d
1 1/2"
3" C
5/8" R
1 1/2"
11/16" CX
15/16" C

Class 53-4**


4" d
2 3/4" C
1" d
2 1/16"
7/16" R
4 1/8" d
2 1/16"
11/16" CX
15/16" C

Class 53-5*

Characteristics	Class 53-1	Class 53-2	Class 53-3	Class 53-4	Class 53-5	Paragraph In Pub. No. C29.1-1944
1. Mechanical Values						
a. Transverse Strength, Pounds	2000	3000	4000	4500	6000	5.1.6
2. Electrical Values						
a. Low-frequency Dry Flashover, Kv	20	25	25	25	35	4.1
b. Low-frequency Wet Flashover, Kv						
1. Vertical	8	12	12	12	18	4.2
2. Horizontal	10	15	15	15	25	4.2

*Side wire groove must seat not less than 13/16-inch diameter mandrel.

†Side wire groove must seat not less than 1-5/16-inch diameter mandrel.

NOTE I—Tolerances
a=1/64 inch
b=1/32 inch
c=1/16 inch
d=⅛ inch
e=3/16 inch
f=¼ inch
g=⅜ inch
h=½ inch
j=¾ inch
k=1 inch
x=0 inch

The use of a single letter indicates the same plus or minus tolerance, for example, a=plus or minus 1/64 inch. Where two letters are used, the first indicates the plus tolerance and the second indicates the minus tolerance, for example, ax=plus 1/64 inch, minus 0 inch.

**Side wire groove must seat not less than 1-3/16-inch diameter mandrel.

STRAIN TYPE

1. SCOPE

1.1 These standards cover strain-type insulators made of wet-process porcelain used in the transmission and distribution of electrical energy.

2. DEFINITIONS

2.1 See Section 2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof, for definition of terms.
(Page 204).

3. GENERAL

3.1 Standard insulators shall conform in all respects to the requirements hereinafter stated. The text, data sheets, and data sheet drawings supplement each other and shall be considered as parts of these standards.

3.2 The data sheet drawings are type drawings, and overall dimensions are shown.

3.3 Manufacturer's drawings, if furnished, shall show the outline of the insulators together with all pertinent dimensions. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

4. MATERIAL

4.1 The insulators shall be made of good commercial grade wet-process porcelain.

4.2 The entire surface of the insulators, with the exception of a firing surface, shall be glazed. The standard color of the glaze shall be brown. The entire surface shall be relatively free from imperfections.

5. DIMENSIONS AND CHARACTERISTICS

5.1 Dimensions and characteristics shall be in accordance with the data sheets.

6. MARKING

6.1 Each insulator shall bear a symbol identifying the manufacturer. The marking shall be legible and durable.

7. PACKING

7.1 Insulators shall be so packed as to prevent injury to them during transportation and handling. Insulators packed in containers conforming to all construction requirements of Consolidated Freight classifications as to bursting tests, size limit and gross weight shall be considered as being adequately packed.

7.2 Each box or container shall be marked with the number of pieces contained therein, the catalogue number, or drawing number, or description of the contents, and the manufacturer's name.

8. MANUFACTURER'S PRODUCTION SAMPLING AND TESTS

8.1 The manufacturer shall make adequate tests to determine that insulators manufactured in accordance with these standards will meet the requirements thereof.

9. SAMPLING, INSPECTION AND TESTS

9.1 **General.** Substantial test experience, over a long period of time, indicates that a total of ½ of one per cent of the number of insulators in a lot is sufficient to establish characteristics demonstrable by destructive tests.

9.2 **Dimensions.** Three insulators shall be selected at random from the lot and their dimensions checked against the dimensions on the manufacturer's drawing. Failure of more than one of these insulators to conform, within manufacturing tolerances, to the dimensions on this drawing shall constitute failue of the lot to meet this standard.

9.3 **Design Tests.** Certified test data on insulators of existing design shall be regarded as equivalent to actual design tests. Design tests on insulators of new design shall be made in accordance with paragraphs 9.3.1 and 9.3.2.

9.3.1 **Low-frequency Dry-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.1 of *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average dry-flashover value of the three insulators to equal or exceed 95 per cent of the rated dry-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.2 **Low-frequency Wet-flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.2 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average wet-flashover value of the three insulators to equal or exceed 90 per cent of the rated wet-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.4 Quality Control Tests

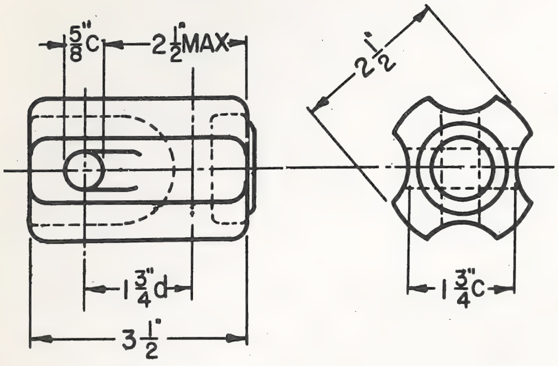
9.4.1 **Visual.** If visual inspection is required on lots of 500 or more insulators, 50 insulators shall be selected at random from the lot. If more than 4 but less than 10 of the insulators fail to meet the requirements of paragraph 4.2, 100 additional insulators shall be selected at random from the same lot. Failure of more than 10 insulators total from both the first and second samples shall constitute failure of the lot to meet this standard.

9.4.2 **Porosity.** Test specimens shall be selected from insulators destroyed in other tests and tested in accordance with Section 5.4 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Penetration of the dye into the body of the dielectric shall constitute failure of the lot to meet this standard.

9.4.3 **Tensile Strength.** Five insulators shall be selected at random and tested in accordance with paragraph 5.1.5 of the *American Standard Insulator Tests,* Publication No. C29.1-1944, or latest revision thereof. Failure of the average strength of the five insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85 per cent of that strength requirement shall constitute failure of the lot to meet this standard.

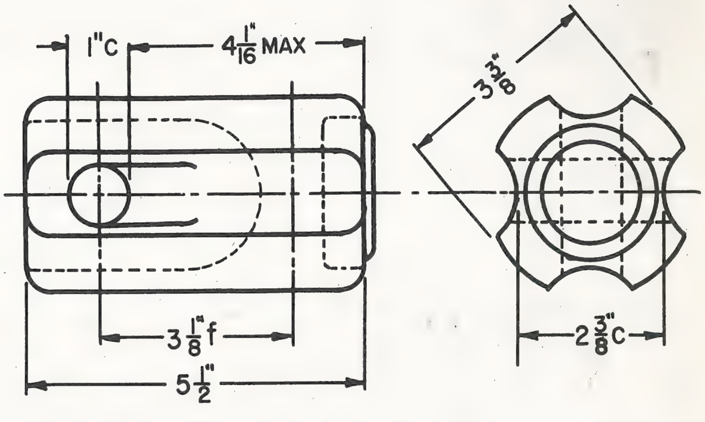
STANDARDS

FOR WET PROCESS PORCELAIN INSULATORS



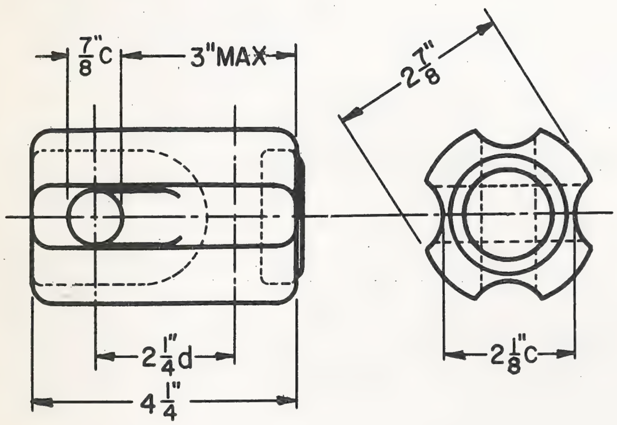
5/8"C
2 1/2" MAX
2 1/2"
1 3/4"d
1 3/4"C
3 1/2"

Class 54-1



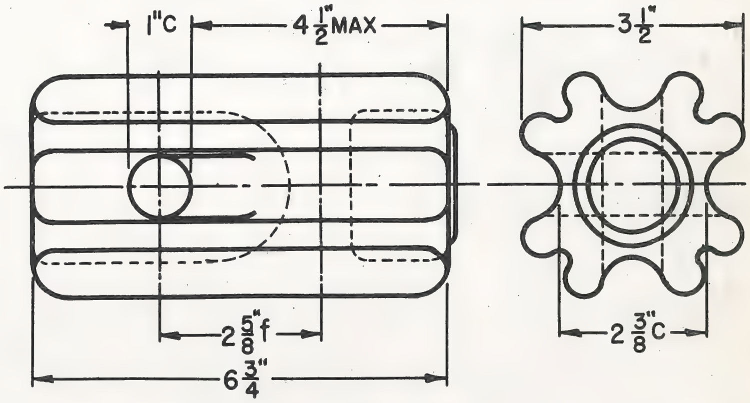
1"C
4 1/16" MAX
3 3/8"
3 1/8"f
5 1/2"
2 3/8"C

Class 54-3



7/8"C
3" MAX
2 7/8"
2 1/4"d
2 1/8"C
4 1/4"

Class 54-2



1"C
4 1/2" MAX
3 1/2"
2 5/8"f
6 3/4"
2 3/8"C

Class 54-4

L
O
C
K
E

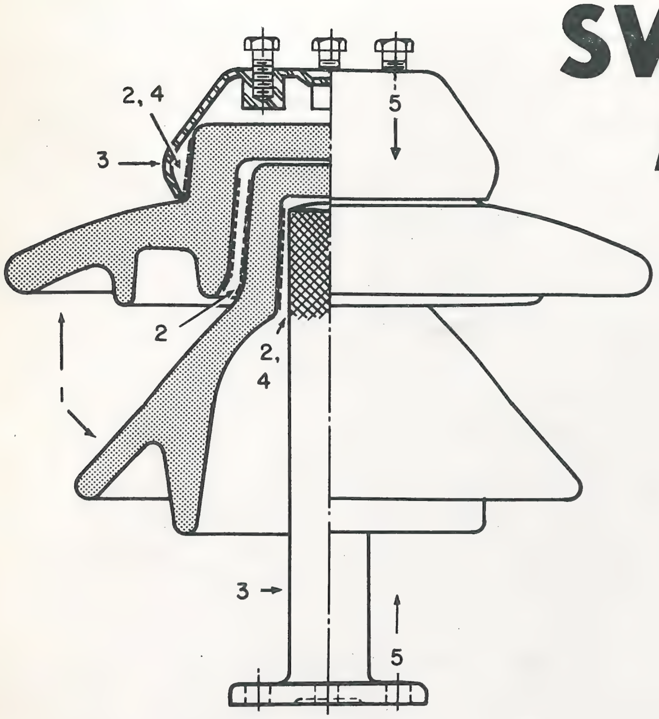
Characteristics	Class 54-1	Class 54-2	Class 54-3	Class 54-4	Paragraph In Pub. No. C29.1-1944
1. MECHANICAL VALUES					
a. Tensile Strength, Pounds	10000	12000	20000	20000	5.1.5
2. ELECTRICAL VALUES					
a. Low-frequency Dry Flashover, Kv	25	30	35	40	4.1
b. Low-frequency Wet Flashover, Kv	12	15	18	23	4.2
c. Leakage Distance, Inches	1⅝	1⅞	2¼	3	2.6.1

NOTE I—Tolerances

a=1/64 inch
b=1/32 inch
c=1/16 inch
d=⅛ inch
e=3/16 inch
f=¼ inch
g=⅜ inch
h=½ inch
x=0 inch

The use of a single letter indicates the same plus or minus tolerance, for example, a=plus or minus 1/64 inch. Where two letters are used, the first indicates the plus tolerance and the second indicates the minus tolerance, for example, ax=plus 1/64 inch, minus 0 inch.

SWITCH AND BUS APPARATUS INSULATORS



CONSTRUCTION DETAILS

Locke switch and bus insulators for outdoor use have a long history of satisfactory, trouble-free service.

Proven design and precise manufacture give these insulators uniformly high mechanical and electrical strength. Here are some of their outstanding features as shown in figure above.

1. High strength porcelain shells, brown compression glazed.

2. Joints between porcelain shells, as well as between porcelain and hardware, are bonded by highest grade cement. Cement joints are cured under controlled conditions to achieve high strength (see page 12).

3. Caps and pins are double hot-dip galvanized to prevent deteriorating corrosive action (see page 17).

4. Where metal parts are joined to porcelain, sand bands provide a firm grip for the cement. A permanently flexible coating separates metal and cement to absorb differences in expansion or shock and to prevent chemical reaction between cement and zinc. It also distributes the load evenly between stressed members.

5. Tapped holes in caps and drilled holes in bases are in vertical alignment. Proper alignment of bolt holes, uniform height and parallel mounting surfaces are assured by the use of precision jigs in manufacture. For illustration see page 25.

STACKING AND NON-STACKING UNITS

Conventional cap and pin type switch and bus insulators are divided into stacking and non-stacking units. Stacking units are designed to develop higher cantilever strength and greater rigidity when used in tall stacks.

Standard units rated up through 46 KV are non-stacking. All stacking units except No. 29511 must be mounted on sub-bases to realize maximum flashover values.

APPARATUS CONNECTIONS

When switch and bus insulators are connected to heavy apparatus, such as transformer or circuit breaker bushings, sufficient flexibility and slack should be provided to allow for differential settling of structures and for thermal changes.

INSULATORS

GENERAL

MOUNTING DETAILS

Holes in cap and pin are arranged on 3″, 5″ or 7″ diameter bolt circles. Threaded holes are tapped 0.010″ oversize so that standard galvanized steel bolts or standard non-ferrous bolts may be used.

DATA TABLE NOTES

RADIO INFLUENCE VALUES

The radio influence values in the tables apply only to new switch and bus insulators tested in the factory, and are the maximum microvolt ratings when tested at the indicated test voltage to ground. Tests are made in accordance with current NEMA-EEI-RMA recommendations on methods of measuring radio noise, NEMA publication #107 and AIEE specification #41, ASA C-29.1-1944 (page 204), or latest revision. The low frequency RMS test voltage values are approximately 10% higher than the line to ground voltage at which these insulators are usually operated. In apparatus applications, the limits for these insulators will be established by the standards of the apparatus.

HIGH RESISTANCE COATINGS

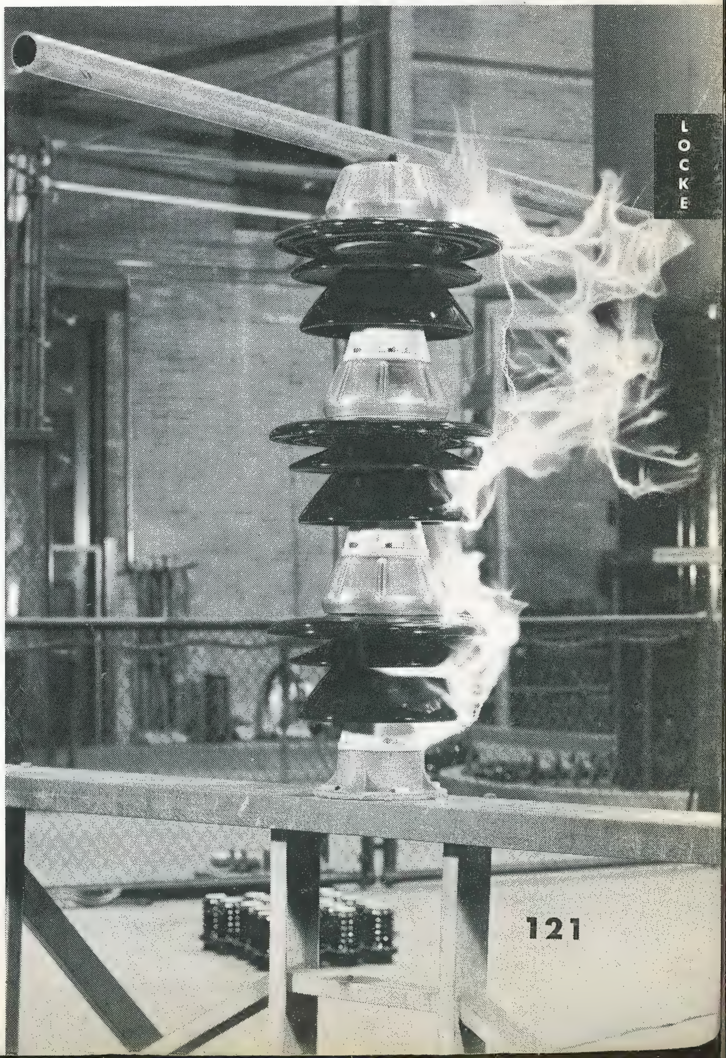
Locke cap and pin type switch and bus insulators comply with NEMA standards for radio noise free insulators. Where high-resistance coatings are applied, the distance over such coatings is considered effective leakage distance.

TOLERANCES

AIEE on flashover values. Plus 3% manufacturing tolerance on all dimensions except height. Plus 5% manufacturing tolerance on weight.

FLASHOVER VALUES

Low frequency one minute dry withstand and ten second wet withstand voltage tests are conducted in accordance with AIEE specification #41, ASA C-29.1-1944 (see page 204), or latest revision.



Dry Flashover Test of Switch Insulators in Locke High Voltage Laboratory.

SWITCH AND BUS
APPARATUS INSULATORS

DATA TABLE NOTES

This includes the use of subbases with the insulators, if they are commonly used to develop full dry arcing distance.

TECHNICAL REFERENCE NUMBER

The Technical Reference Number (T.R. No.) is a NEMA identification for an insulator unit or stack with prescribed characteristics.

VOLTAGE RATING INDEX

N.E.M.A.-E.E.I. Standard Units shown in bold type.

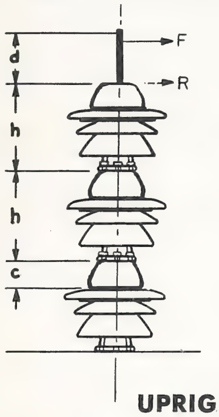
VOLTAGE RATING KV		STANDARD STRENGTH			HIGH STRENGTH			EXTRA HIGH STRENGTH		
Standard	Non-Standard	Cap and Pin	N.E.M.A. T.R. No.	Page No.	Cap and Pin	N.E.M.A. T.R. No.	Page No.	Cap and Pin	N.E.M.A. T.R. No.	Page No.
7.5		**29200**	**1**	**128**	**30200**	**41**	**130**			
	7.5S							32200	58	134
15		**29250**	**4**	**128**	**30250**	**44**	**130**			
23		**29251**	**7**	**128**	**23070**	**46**	**130**			
34.5		**29455**	**10**	**128**	**30455**	**49**	**130**			
	34.5S				2-32200	86	134			
46	46S	**29153** 3-32200	**13** 100	**128** 134	**30153**	**53**	**130**			
69		**2-29511**	**16**	**128**	**2-7785**	**56**	**130**			
	88S 110S	3-8888 4-8888	117 121	134 134						
115		**3-7785**	19	**132**						
161†		**4-7785**	**25**	**132**						
161‡		**1-23082 & 3-7785**	**26**	**132**						
196†		**5-23082**	**27**	**132**						
230†		**6-23082**	**28**	**132**						
287†		**6-23083 & 2-23109**	**33**	**132**						
287§		**6-23083 & 2-23109**	**35**	**132**						

†For vertical mounting ‡For horizontal mounting §For underhung mounting

INSULATORS
GENERAL

CANTILEVER STRENGTH

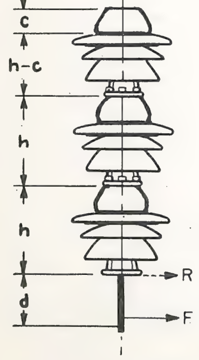
Cantilever strength is often critical in insulator application. All cantilever ratings shown in the tables assume that the load is applied flush with cap or pin. If cantilever loads are applied at any other point, the allowable load at that point will vary inversely as the effective moment arm. The normal fracture location under cantilever loading is near the lip of the cap of the unit at the supported end of the stack. Fig. 24 illustrates a method for calculating cantilever strength in such cases. These tables should be used *only* for stacks of two or more units. For special applications or single units of stacking insulators, refer to factory for recommendations.



R = RATED UPRIGHT CANTILEVER STRENGTH
F = CANTILEVER STRENGTH FOR LOADS APPLIED AT DISTANCE "d" ABOVE TOP OF CAP
h = UNIT HEIGHT
c = CAP HEIGHT
n = NUMBER OF UNITS IN STACK

$$F = R\left[\frac{(n-1)h+c}{(n-1)h+c+d}\right]$$

UPRIGHT MOUNTING



R = RATED CANTILEVER STRENGTH
F = CANTILEVER STRENGTH FOR LOADS APPLIED AT DISTANCE "d" BELOW BASE OF INSULATOR
h = UNIT HEIGHT
c = CAP HEIGHT
n = NUMBER OF UNITS IN STACK

$$F = R\left[\frac{nh-c}{nh-c+d}\right]$$

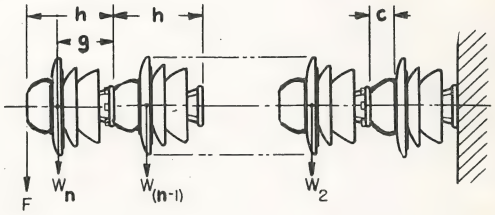
UNDERHUNG MOUNTING

Figure 24

For easy reference, see chart on page 124 or write to Locke for handy cantilever strength calculator.

HORIZONTAL MOUNTING

In horizontal mounting of multiple unit stacks, the bending moment imposed on the base unit by the weight of the other units may form a large portion of the allowable rated moment. Fig. 25 shows a method of calculating external load which can be carried by a stack of units in horizontal position.



R—RATED CANTILEVER STRENGTH
F—RESIDUAL CANTILEVER STRENGTH AVAILABLE FOR SUPPORT OF EXTERNAL LOAD
n—NUMBER OF UNITS IN STACK
h—HEIGHT OF UNIT
c—HEIGHT OF CAP
g—DISTANCE OF CENTER OF GRAVITY OF EACH UNIT ABOVE ITS BASE (60% of h)
$W_1, W_2, W_3 \ldots W_n$ = WEIGHTS OF INDIVIDUAL UNITS COUNTING FROM GROUND END

$$F = \frac{R[(n-1)h+c] - W_2(g+c) - W_3(g+c+h) --- W_n[g+c+(n-2)h]}{(n-1)h+c}$$

IF ALL UNITS HAVE THE SAME WEIGHT THEN

$$W_2 = W_3 = \ldots W_n = W$$

$$\text{AND } F = \frac{R[(n-1)h+c] - W(n-1)\left[\frac{(n-2)h}{2}+g+c\right]}{(n-1)h+c}$$

Figure 25

SWITCH AND BUS APPARATUS INSULATORS

CANTILEVER STRENGTHS ABOVE CAP AND BELOW BASE

CATALOG NUMBER	T. R. No.	Cantilever Strength, Pounds							
		Inches Above Cap				Inches Below Base			
		1	2	3	4	1	2	3	4
23070	46	3250	2720	2400	2160	2700	2450	2250	2100
29153	13	1700	1500	1350	1250	900	825	800	780
29200	1	1710	1525	1400	1300	800	700	600	570
29250	4	1600	1300	1150	1000	800	700	575	500
29251	7	1600	1300	1100	900	800	700	620	575
29455	10	1600	1325	1150	1050	850	750	675	600
30153	53	3400	3000	2650	2400	2350	2150	2050	1950
30200	41	2900	2300	1900	1700	2500	2150	1900	1700
30250	44	3100	2500	2150	1850	2600	2300	2050	1850
30455	49	3250	2750	2440	2240	2700	2500	2300	2200
2-7785	56	2850	2700	2600	2500	2250	2150	2075	2000
3-7785	19	1650	1600	1550	1500	1430	1400	1360	1330
4-7785	25	1170	1150	1130	1100	1050	1030	1010	990
1-23082 & 3-7785	26	1660	1630	1600	1560	1440	1420	1390	1370
5-23082	27	1420	1400	1380	1360	1330	1310	1300	1280
6-23082	28	1150	1140	1120	1110	1090	1070	1060	1050
2-29511	16	1420	1340	1280	1220	960	930	900	860
2-23109 & 6-23083	33	1190	1180	1170	1160	—	—	—	—
2-23109 & 6-23083	35	—	—	—	—	1140	1130	1120	1110

See notes on page 123. For more detailed calculator of cantilever strengths above caps, write to Locke.

INSULATORS

GENERAL

STANDARDS (AND TESTS)

All cap and pin type switch and bus insulators will be furnished in accordance with proposed joint NEMA-EEI specification TDJ-58 (page 143), unless otherwise specified. Test data for all insulators, standard and non-standard, are determined in accordance with ASA C-29.1-1944 (page 204).

Here are some advantages of standard insulator use:

1. The number of insulators you need to stock as replacements is reduced.
2. Switch builders have greater latitude in design, using fewer insulator types.
3. Mass production of standard insulators means better and more efficient delivery service.

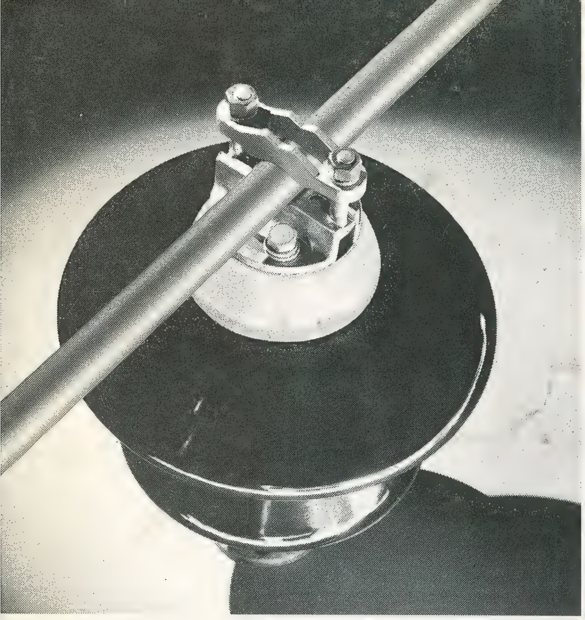
Non-standard insulators for special applications can be furnished on request.

BASIC IMPULSE INSULATION LEVELS

A basic impulse insulation level (BIL) is the impulse voltage which electrical equipment is required to withstand without failure or disruptive discharge, when tested under specified conditions of temperature and humidity. Basic impulse insulation levels are designated in terms of the crest voltage of a 1.5 x 40 microsecond full wave impulse voltage test wave. These levels are subject to continuing study by a joint AIEE-EEI-NEMA committee, as new concepts and additional data on system grounding practices, maximum operating voltages and equipment with reduced insulation levels, are developed.

Operating voltages, arrester levels and basic impulse insulation levels, shown below, are believed to represent up-to-date engineering thinking.

Operating Voltage KV	% Arrester level	BIL
1.2	100	30
2.5	100	45
5	100	60
—	100	75
7.5	100	95
15	100	110
23	100	150
34.5	100	200
46	100	250
69	100	350
92	80	350
92	100	450
115	80	450
115	100	550
138	80	550
138	100	650
161	80	650
161	100	750
230	75	825
230	80	900
230	100	1050
287	75	1050
287	100	1300
330	75	1175
330	80	1300



SWITCH AND BUS APPARATUS INSULATORS

APPLICATION OF OUTDOOR BUS CLAMPS AND FITTINGS

Conductor fittings and adapters for assembly with Locke outdoor switch insulators are listed on pages 138-142. They are used for all accepted methods of mounting outdoor bus and conductor supports—upright, horizontal or underhung.

CONDUCTOR FITTINGS

Generally, listed fittings consist of base and keeper. The base is the part firmly attached to the insulator or to an adapter placed between the unit and the conductor fitting. The keeper is the movable part which holds the conductor to the base. Two-clamp conductor fittings for conductor bars are provided with two keepers.

Keepers are made of non-magnetic material to reduce the heating effect of the magnetic field at the point of support. Bases are made of non-magnetic material or of malleable iron, hot-dip galvanized.

To permit angular adjustment of the conductor, bases of fittings for round conductors have slots for the holding bolts.

The bolts furnished with all non-magnetic fittings are Everdur, except when otherwise noted. Those furnished with "half-non-magnetic" fittings are steel, hot-dip galvanized. The bolts which secure the keeper to its base are square-headed and fit into a channel shaped section of the lower fitting. Cap screws or bolts are furnished to secure the base to the insulator.

MOUNTING ATTACHMENTS

Listed spacers and pipe adapters are made of malleable iron, hot-dip galvanized. Pipe adapters are of the two-bolt type and have serrated gripping surfaces to prevent turning of the adapter on the pipe.

APPLICATION

To protect bus support insulators from damage by excessive cantilever loads due to dimensional changes of the bus, bus runs should be clamped tight at one point of support only. Clamps at other supporting points should permit the bus to slide freely. Where the length of the bus warrants support at its center, in addition to its ends, the bus should be clamped firmly only at the center to permit expansion in either direction. Long bus runs should be divided into sections with suitable expansion joints.

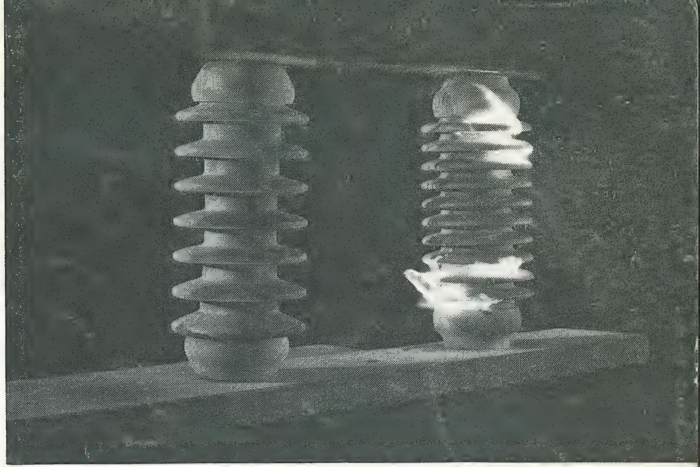
ORDERING DIRECTIONS

Order by Catalog Number.

For reamed-to-size fittings for round conductors, specify outside conductor diameter.

For fittings for rectangular bars, specify the number of bars to be mounted.

INSULATORS
GENERAL



Wet contaminated Flashover test of present Locke Station Post Insulator (left) in parallel with older design. Absence of corona on new design proves its serviceability under such difficult conditions.

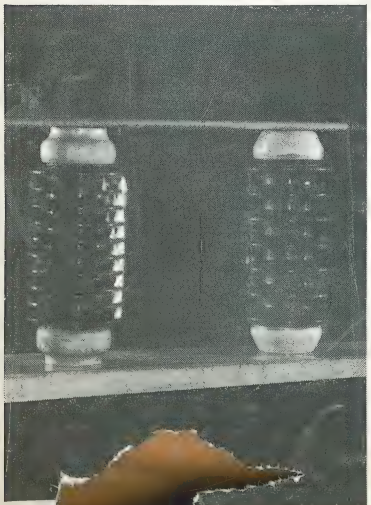
POST TYPE INSULATORS
(STATION POSTS)

With thousands of its station columns in service for over ten years, Locke now brings you an insulator designed to reduce corona and radio interference. It guards against flashover and service interruption, particularly where industrial contamination and fog reduce the effectiveness of older station post designs. It's an insulator you can install . . . and forget.

4 OUTSTANDING FEATURES

WIDER HOOD SPACING

Gives you
(a) More effective natural cleaning by wind and rain.
(b) Easier hot line washing.
(c) Less tendency to bridge or to leak through drip paths—radio quiet.
(d) Less tendency to fill between skirts with soil, snow, sleet.
(e) Increased effectiveness of leakage surface—the key to better performance—even on units with reduced leakage distance.



In wet flashover test under identical standard conditions (A.S.A. Std. 29.1-1944), wider hood spacing of modern Locke design (right) breaks drip stream, tending to eliminate heavy corona formation.

EFFECTIVE SEAL

The heart of any station column is its effective seal. Locke seals the internal cavity with a galvanized steel disk, bonded permanently across the open end of the porcelain column. The special adhesive used has proven itself as a sealer of airplane gas tanks and electrical equipment. Combined with an active drying agent within the cavity which keeps the dew point below freezing temperature, the unique Locke seal assures full dielectric strength throughout the insulator's life, and puncture proof performance even under direct lightning strokes.

HOUR GLASS SHAPE

Slightly tapered design of vertical member places heavier sections at the point of greatest mechanical stress, makes most effective use of porcelain. More effective leakage surface distribution is obtained, electrical stress is spread more uniformly. The result is lighter weight without loss of strength, quiet operation and less trouble from leakage and sparking.

RUGGED DRAWN STEEL CAPS

Lighter weight, uniform strength and smooth, evenly galvanized surface combine to give you a more reliable and attractive insulator.

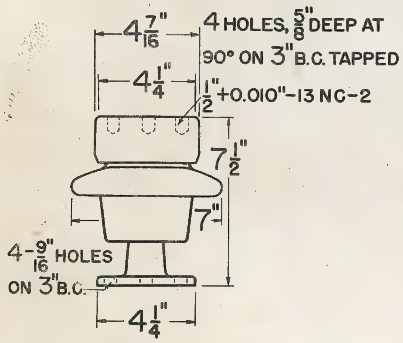
Locke station posts are listed on pages 136-137.

SWITCH AND BUS APPARATUS INSULATORS

STANDARD STRENGTH

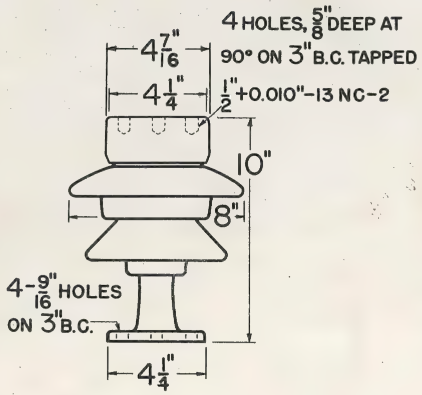
BIL UNITS—NEMA STD.

7.5 – 69 KV.



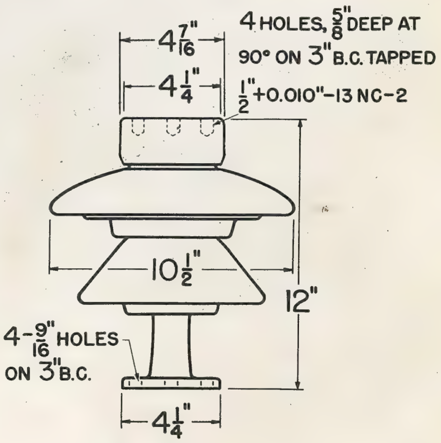
4 7/16"
4 HOLES, 5/8" DEEP AT 90° ON 3" B.C. TAPPED 1/2"+0.010"-13 NC-2
4 1/4"
7 1/2"
7"
4-9/16" HOLES ON 3" B.C.
4 1/4"

NO. 29200



4 7/16"
4 HOLES, 5/8" DEEP AT 90° ON 3" B.C. TAPPED 1/2"+0.010"-13 NC-2
4 1/4"
10"
8"
4-9/16" HOLES ON 3" B.C.
4 1/4"

NO. 29250



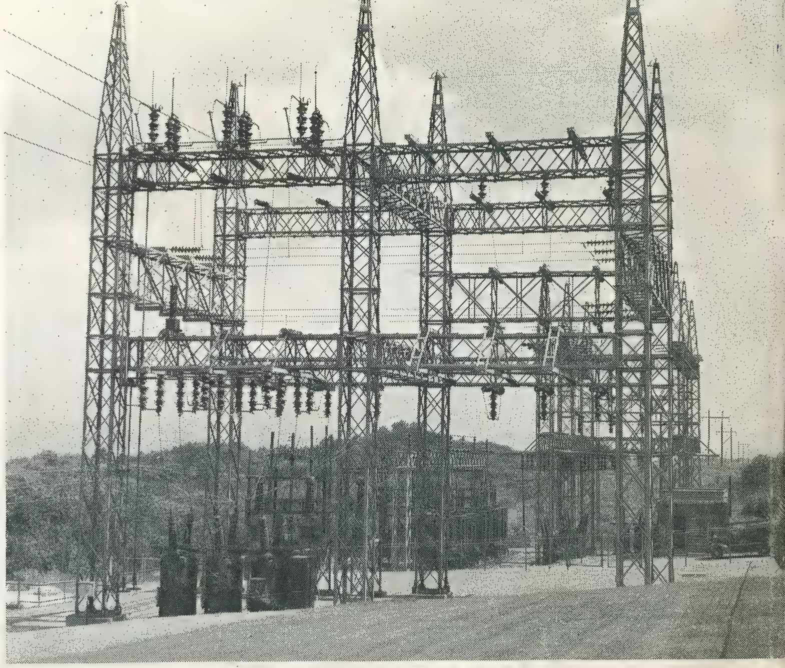
4 7/16"
4 HOLES, 5/8" DEEP AT 90° ON 3" B.C. TAPPED 1/2"+0.010"-13 NC-2
4 1/4"
10 1/2"
12"
4-9/16" HOLES ON 3" B.C.
4 1/4"

NO. 29251

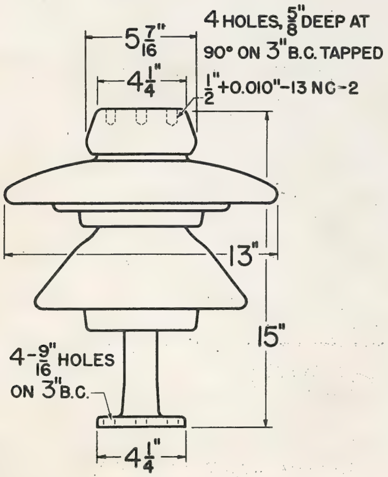
Catalog Number	Voltage Rating KV	NEMA T. R. No.	Flashover—KV				Withstand Voltage—KV			Radio Influence Voltage	
			Low Frequency		Impulse		Low Frequency		Impulse	Test KV to Ground	Max. MV at 1000 Kc
			Dry	Wet	Pos.	Neg.	Dry 1 Min.	Wet 10 Sec.			
29200	7.5	1	60	40	105	120	35	30	95	5	50
29250	15	4	85	55	125	200	50	45	110	10	50
29251	23	7	110	75	170	250	70	60	150	15	100
29455	34.5	10	145	100	225	290	95	80	200	22	100
29153	46	13	170	125	280	340	120	100	250	30	200
2 of 29511	69	Stack 16 Unit 147	235	180	390	475	175	145	350	44	200

INSULATORS

CAP AND PIN TYPE

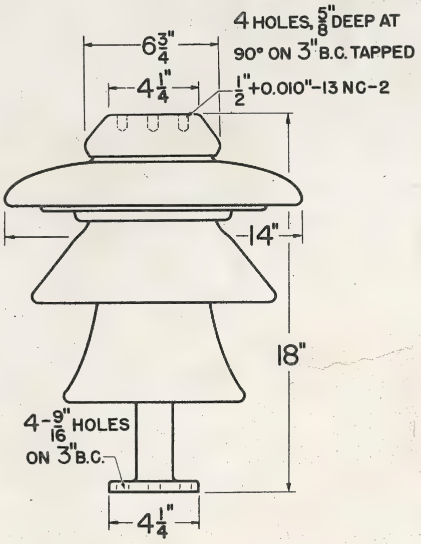


Cap screws are not furnished as standard equipment, except on #29511. Cantilever strengths above cap and below base are shown on page 124. See Data Table Notes on page 121.



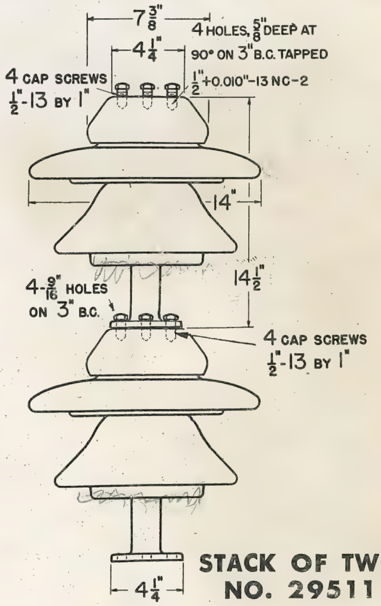
5 7/16"
4 HOLES, 5/8" DEEP AT 90° ON 3" B.C. TAPPED
4 1/4"
1/2"+0.010"-13 NC-2
13"
15"
4-9/16" HOLES ON 3" B.C.
4 1/4"

NO. 29455



4 HOLES, 5/8" DEEP AT 90° ON 3" B.C. TAPPED
6 3/4"
4 1/4"
1/2"+0.010"-13 NC-2
14"
18"
4-9/16" HOLES ON 3" B.C.
4 1/4"

NO. 29153

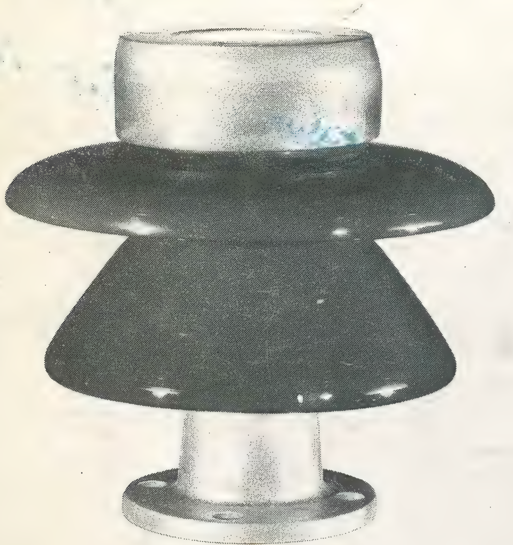


7 3/8"
4 HOLES, 5/8" DEEP AT 90° ON 3" B.C. TAPPED
4 1/4"
4 CAP SCREWS 1/2"-13 BY 1"
1/2"+0.010"-13 NC-2
14"
14 1/2"
4-9/16" HOLES ON 3" B.C.
4 CAP SCREWS 1/2"-13 BY 1"
4 1/4"

STACK OF TWO NO. 29511

Mechanical Strength					Leakage Distance Inches	Dry Arcing Distance Inches	Weight Each—Lbs.		Std. Pkg. Quan.
Cantilever—Lbs.		Torsion In—Lbs.	Tension Lbs.	Comp. Lbs.			Net	Pkd.	
Upright	Underhung								
2000	1000	6000	5000	10000	7½	5¼	11	12	6
2000	1000	7000	5000	10000	12	7¼	17	18	4
2000	1000	8000	5000	10000	20	9½	25	30	3
2000	1000	10000	7000	15000	28	14	39	45	2
2000	1000	12000	8000	15000	36	17	54	63	1
1500	1000	15000	12000	25000	52	28	48	54	2

310

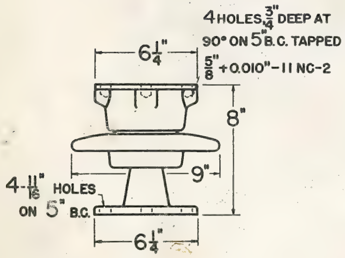


SWITCH AND BUS APPARATUS INSULATORS

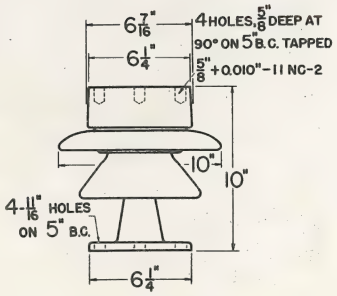
HIGH STRENGTH

BIL UNITS—NEMA STD.

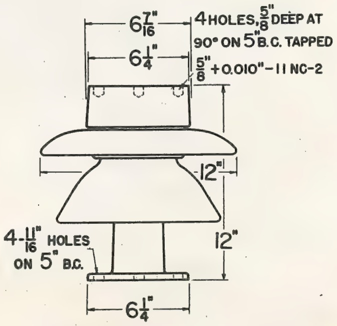
7.5 — 69 KV.


6¼"
4 HOLES, ¾" DEEP AT 90° ON 5" B.C. TAPPED ⅝" +0.010"-11 NC-2
8"
9"
4-11/16" HOLES ON 5" B.C.
6¼"

NO. 30200


6 7/16"
6¼"
4 HOLES, ⅝" DEEP AT 90° ON 5" B.C. TAPPED ⅝" +0.010"-11 NC-2
10"
10"
4-11/16" HOLES ON 5" B.C.
6¼"

NO. 30250


6 7/16"
6¼"
4 HOLES, ⅝" DEEP AT 90° ON 5" B.C. TAPPED ⅝" +0.010"-11 NC-2
12"
12"
4-11/16" HOLES ON 5" B.C.
6¼"

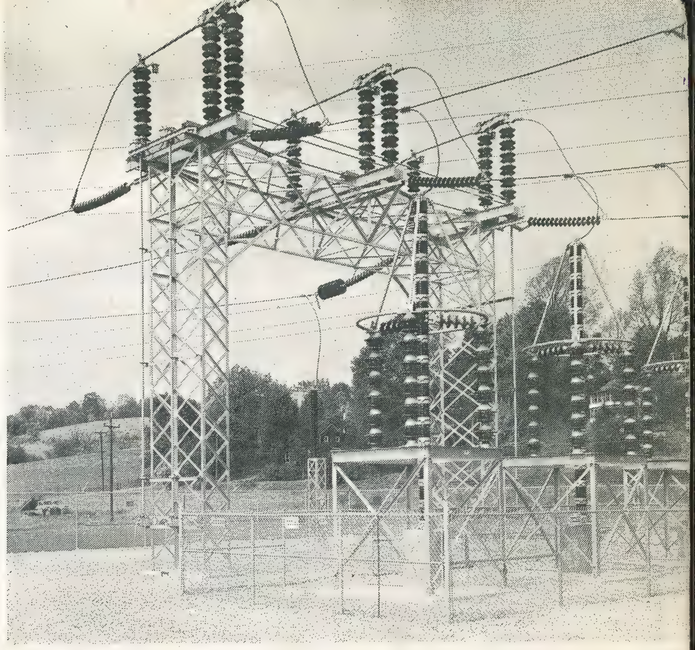
NO. 23070

30251

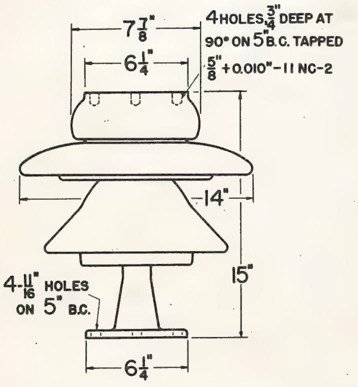
Catalog Number	Voltage Rating KV	NEMA T. R. No.	Flashover—KV				Withstand Voltage—KV			Radio Influence Voltage	
			Low Frequency		Impulse		Low Frequency		Impulse	Test KV to Ground	Max. MV at 1000 Kc
			Dry	Wet	Pos.	Neg.	Dry 1 Min.	Wet 10 Sec.			
30200	7.5	41	60	40	105	120	35	30	95	5	50
30250	15	44	85	55	125	200	50	45	110	10	50
23070	23	46	110	75	170	250	70	60	150	15	100
30455	34.5	49	145	100	225	290	95	80	200	22	100
30153	46	53	170	125	280	340	120	100	250	30	200
2 of 7785	69	56	280*	190*	410*	540*	205*	160*	350*	44	200

* These values obtained with insulators mounted on 3½" subbase, which must be ordered separately. See page 140.

INSULATORS
CAP AND PIN TYPE

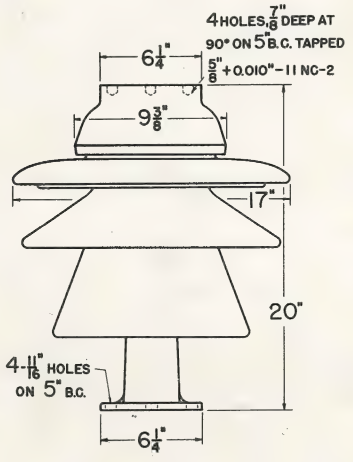


Cap screws are not furnished as standard equipment, except on #7785. Cantilever strengths above cap and below base are shown on page 124. See Data Table Notes on page 121.



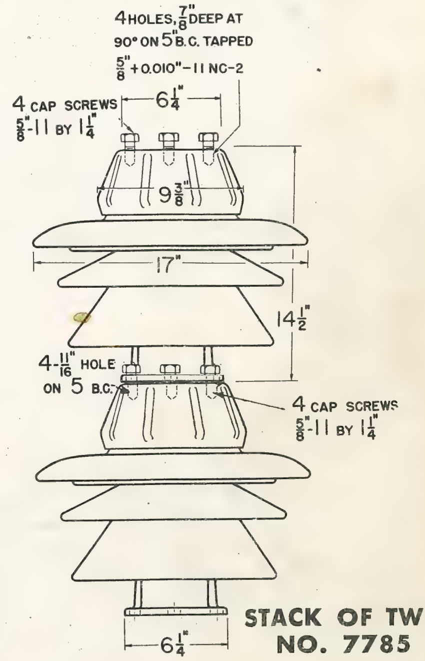
7 7/8"
6 1/4"
4 HOLES 3/4" DEEP AT 90° ON 5" B.C. TAPPED 5/8" + 0.010" - 11 NC-2
14"
15"
4-11/16" HOLES ON 5" B.C.
6 1/4"

NO. 30455



4 HOLES 7/8" DEEP AT 90° ON 5" B.C. TAPPED 5/8" + 0.010" - 11 NC-2
6 1/4"
9 3/8"
17"
20"
4-11/16" HOLES ON 5" B.C.
6 1/4"

NO. 30153

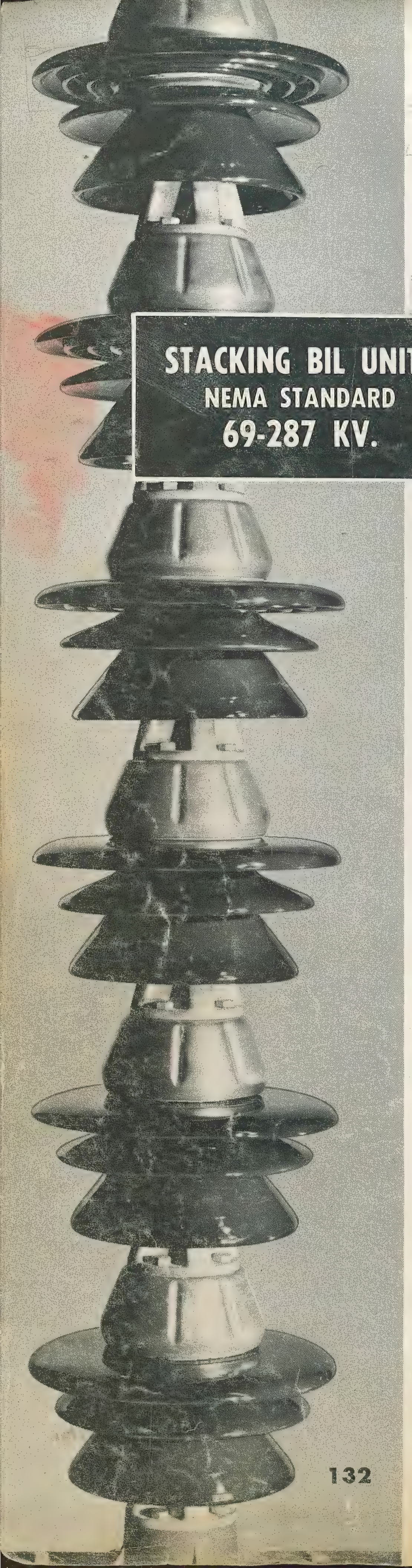


4 HOLES 7/8" DEEP AT 90° ON 5" B.C. TAPPED 5/8" + 0.010" - 11 NC-2
4 CAP SCREWS 5/8"-11 BY 1 1/4"
6 1/4"
9 3/8"
17"
14 1/2"
4-11/16" HOLE ON 5 B.C.
4 CAP SCREWS 5/8"-11 BY 1 1/4"
6 1/4"

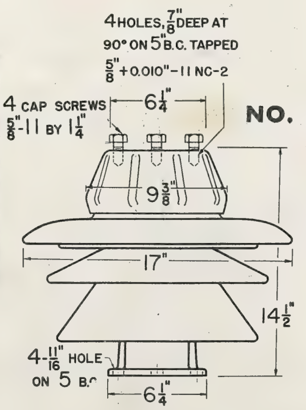
STACK OF TWO NO. 7785

Mechanical Strength					Leakage Distance Inches	Dry Arcing Distance Inches	Weight Each—Lbs.		Std. Pkg. Quan.
Cantilever—Lbs.		Torsion In—Lbs.	Tension Lbs.	Comp. Lbs.			Net	Pkd.	
Upright	Underhung								
4000	3000	12000	10000	20000	8	5½	23	31	4
4000	3000	14000	10000	20000	14	7½	31	39	4
4000	3000	16000	10000	20000	18	10½	36	43	2
4000	3000	20000	14000	30000	28	13½	55	71	2
4000	2500	20000	15000	30000	40	18	89	109	1
3000	2350	40000	20000	60000	66	29	80	91	1

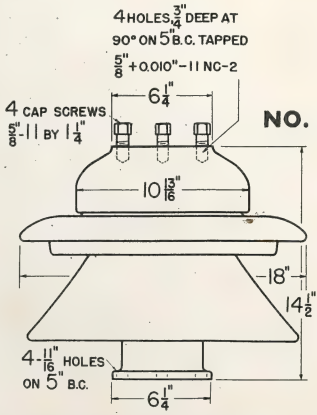
SWITCH AND BUS APPARATUS INSULATORS



STACKING BIL UNITS
NEMA STANDARD
69-287 KV.


4 HOLES, 7/8" DEEP AT
90° ON 5" B.C. TAPPED
5/8" +0.010"-11 NC-2
4 CAP SCREWS
5/8"-11 BY 1 1/4"
6 1/4"
9 3/8"
17"
14 1/2"
4-11/16" HOLE
ON 5 B.C
6 1/4"

NO. 7785

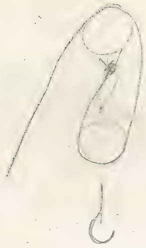

4 HOLES, 3/4" DEEP AT
90° ON 5" B.C. TAPPED
5/8" +0.010"-11 NC-2
4 CAP SCREWS
5/8"-11 BY 1 1/4"
6 1/4"
10 13/16"
18"
14 1/2"
4-11/16" HOLES
ON 5" B.C.
6 1/4"

NO. 23082

No. of Units in Stack	STACK CHARACTERISTICS—Values for entire stack							
	Catalog Number	Suggested KV Rating	NEMA T.R. No.	Height Inches	Flashover—KV**			
					Low Frequ.		Impulse	
					Dry	Wet	Pos.	Neg.
2	29511	69	16	29	235	180	390	475
1	7785	—	140	14½	160	95	235	290
2	7785	69	56	29	280	190	410	540
3	7785	115	19	43½	385	285	610	780
4	7785	138/161	25	58	485	380	810	1020
5	7785	196	126	72½	575	475	1010	1240
6	7785	230	128	87	660	570	1210	1450
1	23082	—	141	14½	160	95	235	290
2	23082	69	*	29	280	190	410	540
3	23082	115	*	43½	385	285	610	780
4	23082	138/161	123	58	485	380	810	1020
5	23082	196	27	72½	575	475	1010	1240
6	23082	230	28	87	660	570	1210	1450
7	23082	230	131*	101½	745	660	1410	1650
8	23082	287	*	116	830	740	1610	1850
4	1-23082 3-7785	138/161	26*	58	475	370	780	980
1	23083	—	142*	14½	160	95	235	290
2	23083	69	*	29	280	190	410	540
3	23083	115	*	43½	385	285	610	780
4	23083	138/161	*	58	485	380	810	1020
5	23083	196	*	72½	575	475	1010	1240
6	23083	230	129	87	660	570	1210	1450
7	23083	230	133	101½	745	660	1410	1650
8	23083	287	135	116	830	740	1610	1850
1	23109	*	144	14½				
8	6-23083 2-23109	287	33 Upr† 35 Und‡	117⅜	830	740	1610	1850

* Non NEMA Standard.

** Flashover and withstand voltage values for stacks rated above 69 KV are predicated on the use of a 3½" high subbase, (page 141), or its equivalent.



775
500
275

INSULATORS
CAP AND PIN TYPE

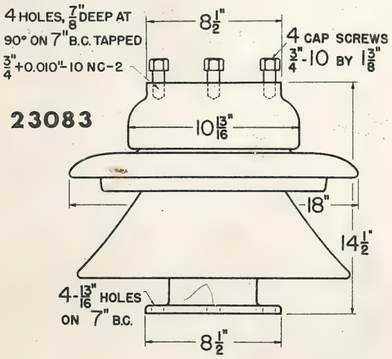
Refer to Data Table Notes, page 121.

Horizontal mounting is not recommended for stacks of more than three units.

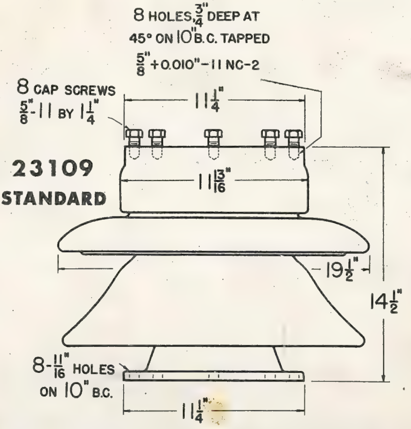
Cap screws are furnished as Standard. Tapped holes in caps and drilled holes in bases are in vertical alignment.

5

NO. 23083


4 HOLES, 7/8" DEEP AT
90° ON 7" B.C. TAPPED
3/4" +0.010" - 10 NC-2
8 1/2"
4 CAP SCREWS
3/4"-10 BY 1 3/8"
10 13/16"
18"
14 1/2"
4-13/16" HOLES
ON 7" B.C.
8 1/2"

NO. 23109
NON-STANDARD


8 HOLES, 3/4" DEEP AT
45° ON 10" B.C. TAPPED
5/8" +0.010" - 11 NC-2
8 CAP SCREWS
5/8"-11 BY 1 1/4"
11 1/4"
11 13/16"
19 1/2"
14 1/2"
8-11/16" HOLES
ON 10" B.C.
11 1/4"

STACK CHARACTERISTICS—Values for entire stack												UNIT CHARACTERISTICS					No of Units in Stack
Withstand—KV**			Radio Infl. Voltage		Mechanical Strength					Leakage Dist. In.	Dry Arc. Dist. In.	Lkg. Dist. In.	Dry Arc. Dist. In.	Lbs. Each		Std. Pkg. Quan.	
Low Frequ.		Impulse	Test KV to Ground	Max. MV at 1000 Kc	Cantilever—Lbs.		Torsion in 1000 In—Lbs.	Tension in 1000 Lbs.	Comp. in 1000 Lbs.					Net	Pkd.		
Dry 1 Min.	Wet 10 Sec.				Upright	Underhung											
175	145	350	44	200	1500	1000	15	12	25	52	28	26	13¾	48	54	2	2
115	75	210	22	100	7000	4000	40	20	60	33	14¾	33	14¾	80	91	1	1
205	160	350	44	200	3000	2350	40	20	60	66	29						2
280	230	550	73	200	1700	1470	40	20	60	99	44						3
385	315	750	103	500	1200	1070	40	20	60	132	58						4
465	385	900	125	500	910	840	40	20	60	165	73						5
545	455	1050	146	500	750	700	40	20	60	198	87						6
115	75	210	22	100	10000	6000	90	25	75	33	16	33	16	114	128	1	1
205	160	350	44	200	4500	3500	90	25	75	66	30						2
280	230	550	73	200	2900	2400	90	25	75	99	45						3
385	315	750	103	500	2000	1750	90	25	75	132	59						4
465	385	900	125	500	1450	1350	90	25	75	165	74						5
545	455	1050	146	500	1170	1100	90	25	75	198	88						6
610	525	1300	180	1000	1000	950	90	25	75	231	103						7
680	590	1470	210	1000	900	860	90	25	75	264	117						8
375	305	725	103	500	1700	1470	40	20	60	132	58						4
115	75	210	22	100	10000	6000	90	25	75	33	16	33	16	117	131	1	1
205	160	350	44	200	4500	3500	90	25	75	66	30						2
280	230	550	73	200	2900	2400	90	25	75	99	45						3
385	315	750	103	500	2000	1750	90	25	75	132	59						4
465	385	900	125	500	1450	1350	90	25	75	165	74						5
545	455	1050	146	500	1170	1100	90	25	75	198	88						6
610	525	1300	180	1000	1000	950	90	25	75	231	103						7
680	590	1470	210	1000	900	860	90	25	75	264	117						8
												30	14½	144	183	1	1
680	590	1470	210	1000	1170	1100	90	25	75	258	117						8

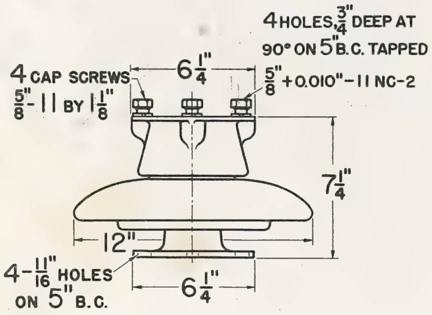
† This stack is for upright base mounting with a 10″ to 7″ transition plate No. 27472 (T.R. No. 151), shown on page 141.

‡ This stack is for underhung mounting with a 10″ to 7″ transition plate No. 27473 (T.R. No. 152), shown on page 141.

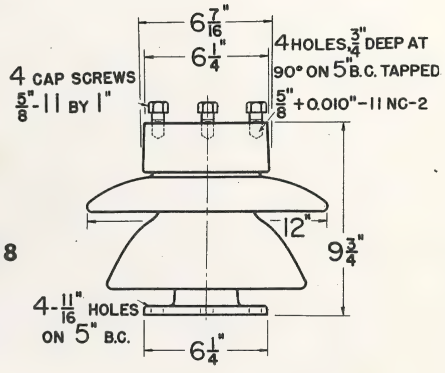
SWITCH AND BUS APPARATUS INSULATORS

UNITS FOR SPECIAL APPLICATIONS

NO. 32200

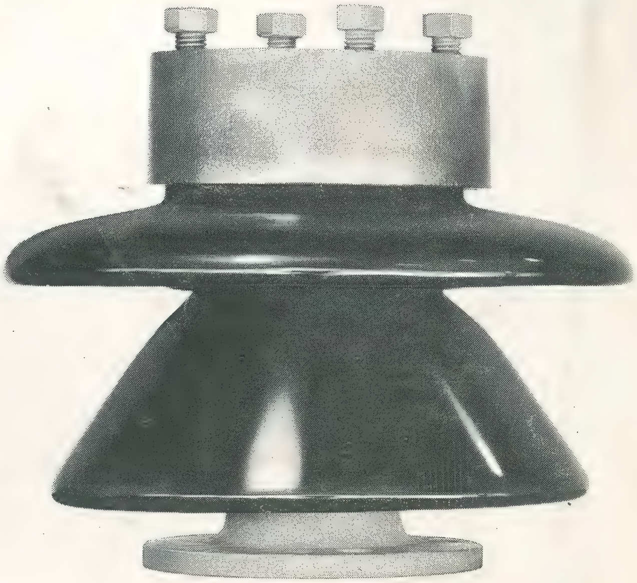

4 HOLES, 3/4" DEEP AT 90° ON 5" B.C. TAPPED
4 CAP SCREWS 5/8"-11 BY 1 1/8"
6 1/4"
5/8" + 0.010"-11 NC-2
7 1/4"
12"
4-11/16" HOLES ON 5" B.C.
6 1/4"

NO. 8888


6 7/16"
6 1/4"
4 HOLES, 3/4" DEEP AT 90° ON 5" B.C. TAPPED
4 CAP SCREWS 5/8"-11 BY 1"
5/8" + 0.010"-11 NC-2
12"
9 3/4"
4-11/16" HOLES ON 5" B.C.
6 1/4"

Catalog Number	No. of Units	NEMA T.R. No.	Leakage Distance Inches	Dry Arcing Distance Inches	Mechanical Strength			Weight—Lbs.		Std. Pkg. Quan.
					Torsion In—Lbs.	Tension Lbs.	Comp. Lbs.	Net	Pkd.	
32200	1	58	13.5	7½	20000	12000	25000	27	35	4
	2	86	27	14¾	—	—	—	54	—	—
	3	100	40.5	22	—	—	—	81	—	—
	4	—	54	29¼	—	—	—	108	—	—
	5	—	67.5	36½	—	—	—	135	—	—
8888	1	145	18	9½	16000	10000	20000	33	39	3
	2	—	36	19¼	—	—	—	66	—	—
	3	117	54	29	—	—	—	99	—	—
	4	121	72	38¾	—	—	—	132	—	—
	5	—	90	48½	—	—	—	155	—	—

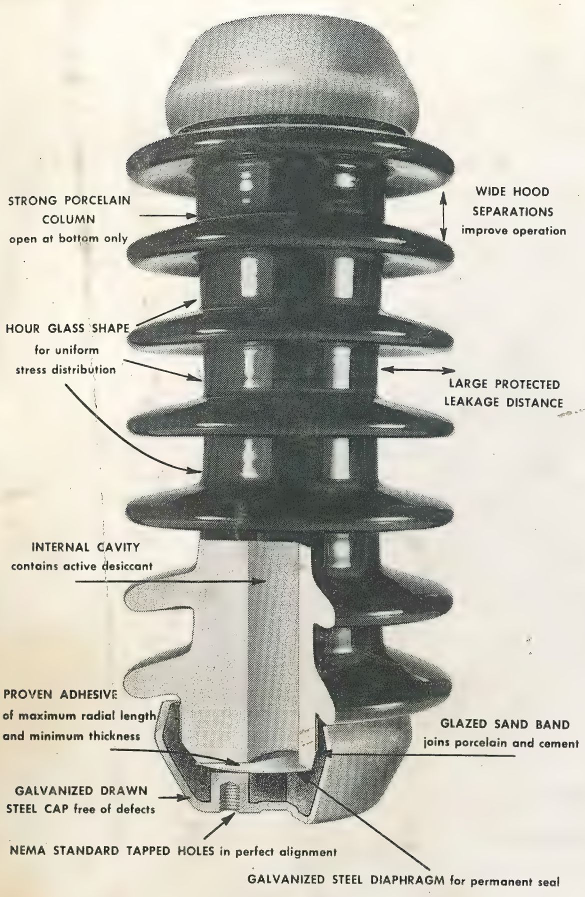
INSULATORS
CAP AND PIN TYPE



Cap screws are furnished as standard equipment. See Data Table Notes on page 121.

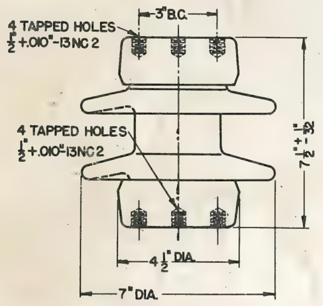
Flashover—KV				Withstand Voltage—KV			Cantilever Strength Lbs.		Radio Influence Volt.	
Low Frequency		Impulse		Low Frequency		Impulse			Test KV to Ground	Max. MV at 1000 Kc
Dry	Wet	Pos.	Neg.	Dry 1 Min.	Wet 10 Sec.		Upright	Underhung		
75	45	125	135	35	30	95	6000	4000	5	50
135	85	230	275	70	60	190	3000	2400	22	100
195	125	320	375	—	—	—	1800	1600	—	—
255	160	410	490	—	—	—	1250	1100	—	—
310	200	500	600	—	—	—	1000	900	—	—
100	60	155	200	70	45	140	4000	3000	15	100
195	120	305	390	—	—	—	1750	1300	—	—
280	180	425	550	240	145	375	975	800	56	200
350	235	525	675	280	190	450	675	600	70	200
415	290	625	800	—	—	—	520	475	—	—

SWITCH AND BUS
APPARATUS INSULATORS



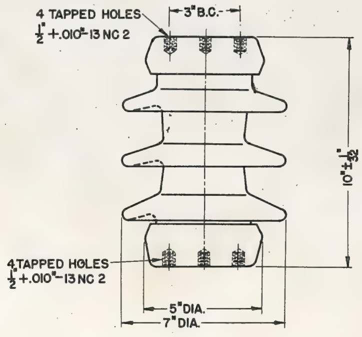
STRONG PORCELAIN COLUMN open at bottom only
WIDE HOOD SEPARATIONS improve operation
HOUR GLASS SHAPE for uniform stress distribution
LARGE PROTECTED LEAKAGE DISTANCE
INTERNAL CAVITY contains active desiccant
PROVEN ADHESIVE of maximum radial length and minimum thickness
GLAZED SAND BAND joins porcelain and cement
GALVANIZED DRAWN STEEL CAP free of defects
NEMA STANDARD TAPPED HOLES in perfect alignment
GALVANIZED STEEL DIAPHRAGM for permanent seal

STANDARD STRENGTH
7.5 – 69 KV.



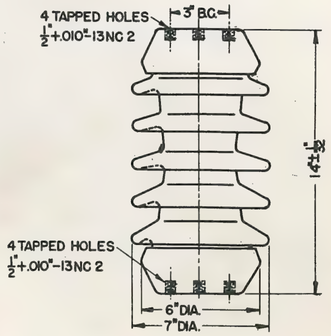
4 TAPPED HOLES
1/2"+.010"-13NC 2
3" B.C.
4 TAPPED HOLES
1/2"+.010"-13NC 2
7 1/2" + 1/32"
4 1/2" DIA.
7" DIA.

NO. 29075



4 TAPPED HOLES
1/2"+.010"-13 NC 2
3" B.C.
10" + 1/32"
4 TAPPED HOLES
1/2"+.010"-13 NC 2
5" DIA.
7" DIA.

NO. 29015

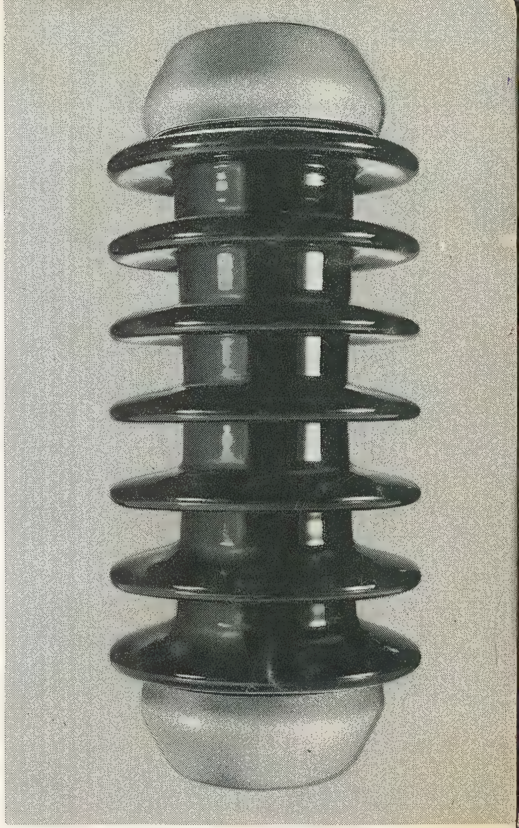


4 TAPPED HOLES
1/2"+.010"-13NC 2
3" B.C.
14 1/32"
4 TAPPED HOLES
1/2"+.010"-13NC 2
6" DIA.
7" DIA.

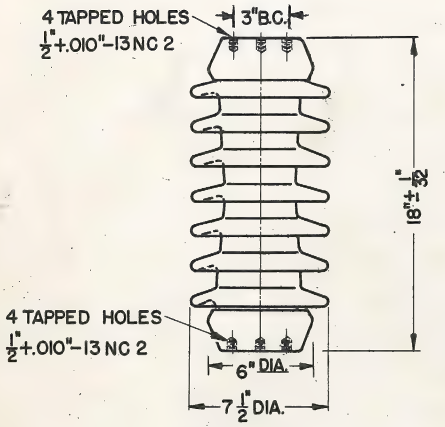
NO. 29023

Catalog Number	Voltage Rating KV	Flashover—KV				Withstand Voltage—KV			Radio Influence Volt.	
		Low Frequency		Impulse		Low Frequency		Impulse	Test KV to Ground	Max. MV at 1000 Kc
		Dry	Wet	Pos.	Neg.	Dry 1 Min.	Wet 10 Sec.			
29075	7.5	60	40	105	120	35	30	95	5	50
29015	15	85	55	125	200	50	45	110	10	50
29023	23	110	75	170	250	70	60	150	15	100
29034	34.5	145	100	225	290	95	80	200	22	100
29046	46	170	125	280	340	120	100	250	30	200
29069	69	235	180	390	475	175	145	350	44	200

INSULATORS
STATION POST TYPE

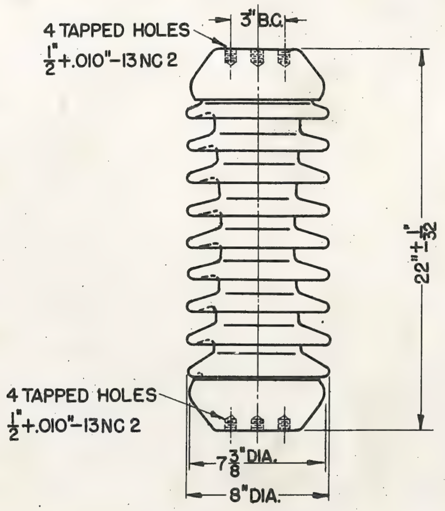


The improved design of the new Locke station post type switch and bus insulator gives you everything you want in a modern station post—improved performance and improved sealing. For comparative tests of new and outmoded station post designs, and for further detail, see page 127.



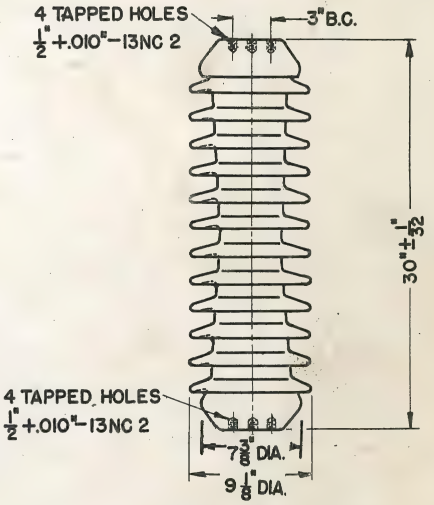
4 TAPPED HOLES
$\frac{1}{2}$"+.010"–13 NC 2
3"B.C.
18"±$\frac{1}{32}$"
4 TAPPED HOLES
$\frac{1}{2}$"+.010"–13 NC 2
6" DIA.
7$\frac{1}{2}$" DIA.

NO. 29034



4 TAPPED HOLES
$\frac{1}{2}$"+.010"–13 NC 2
3"B.C.
22"±$\frac{1}{32}$"
4 TAPPED HOLES
$\frac{1}{2}$"+.010"–13 NC 2
7$\frac{3}{8}$" DIA.
8" DIA.

NO. 29046



4 TAPPED HOLES
$\frac{1}{2}$"+.010"–13 NC 2
3" B.C.
30"±$\frac{1}{32}$"
4 TAPPED HOLES
$\frac{1}{2}$"+.010"–13 NC 2
7$\frac{3}{8}$" DIA.
9$\frac{1}{8}$" DIA.

NO. 29069

Mechanical Strength				Tension Proof Test Load Lbs.	Leakage Distance Inches	Dry Arcing Distance Inches	Weight Each—Lbs.		Std. Pkg. Quan.
Cantilever Lbs.	Tension Lbs.	Torsion In—Lbs.	Comp. Lbs.				Net	Pkd.	
2000	5000	6000	10000	1250	10½	6	12½	13½	6
2000	5000	7000	10000	1250	15½	7¼	17½	19	4
2000	5000	8000	10000	1250	22	10½	29	33	3
2000	7000	10000	15000	1750	33	14½	37	42	2
2000	8000	12000	15000	2000	43	17	59	64	1
1500	12000	15000	25000	2000	67	26	84	94	1

SWITCH AND BUS

OUTDOOR BUS CLAMPS

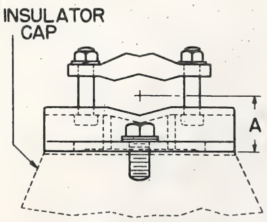
FOR CLAMPING OF PIPE AND BARE STRAND

For attaching round bus or conductor to top or bottom of insulator units in assembly of outdoor bus supports.

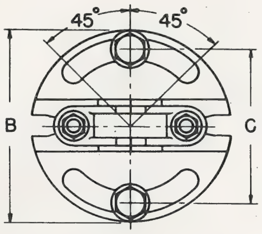
The top of the fittings is made of nonferrous material, which materially reduces the heating effect of the magnetic field at the point of support. The base of all fittings is made of nonferrous material or of galvanized malleable iron.

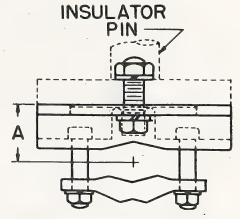
Bolts furnished with the all-nonmagnetic fittings are Everdur. Those furnished with the half-nonmagnetic fittings are hot-dip galvanized steel. For other details, see page 126.

Fittings for other sizes—and for 2, 3 or 4 conductors—are available.



UPRIGHT



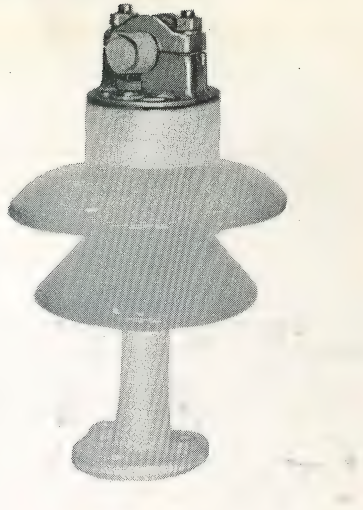


UNDERHUNG

	Conductor Size			Catalog Numbers				Dimensions—In.			Ship. Wt. Ea. Lbs.
	I. P. S. Tubing Inches	Max. O. D. Inches	Bare Cable MCM	Half Nonmagnetic		All Nonmagnetic		A	B	C	
				For Upright Insulators	For Underhung Insulators	For Upright Insulators	For Underhung Insulators				
For insulators with 3 inch Bolt Circle	—	.540	250	6026206G1	6026206G9	6052744G1	6052744G9	1 3/8	4 1/4	3	3
	1/2	.840	500	6026206G3	6026206G11	6052744G3	6052744G11	1 1/2	4 1/4	3	3
	3/4	1.050	750	6026206G4	6026206G12	6052744G4	6052744G12	1 5/8	4 1/4	3	3
	1	1.315	1250	6026206G5	6026206G13	6052744G5	6052744G13	1 3/4	4 1/4	3	4
	1 1/4 to 1 1/2	1.900	2000	6026206G6	6026206G14	6052744G6	6052744G14	2 1/8	4 1/4	3	4
	2	2.375	—	6026206G7	6026206G15	6052744G7	6052744G15	2 3/8	4 1/4	3	4
	2 1/2	2.875	—	6026206G8	6026206G16	6052744G8	6052744G16	2 5/8	4 1/4	3	5
For insulators with 5 inch Bolt Circle	—	.580	250	6026206G17	6026206G28	6052744G17	6052744G28	1 3/8	6 1/4	5	7
	1/2	.840	500	6026206G19	6026206G30	6052744G19	6052744G30	1 3/4	6 1/4	5	7
	3/4	1.050	750	6026206G20	6026206G31	6052744G20	6052744G31	1 7/8	6 1/4	5	7
	1	1.315	1250	6026206G21	6026206G32	6052744G21	6052744G32	2	6 1/4	5	7
	1 1/4 to 1 1/2	1.900	2000	6026206G22	6026206G33	6052744G22	6052744G33	2 1/4	6 1/4	5	7
	2	2.375	—	6026206G23	6026206G34	6052744G23	6052744G34	2 1/2	6 1/4	5	7
	2 1/2	2.875	—	6026206G24	6026206G35	6052744G24	6052744G35	2 3/4	6 1/4	5	7
	3	3.500	—	OBSOLETE		6052744G25	6052744G36	3 1/8	6 1/4	5	8
	3 1/2	4.000	—	OBSOLETE		6052744G26	6052744G37	3 3/8	6 1/4	5	8
	4	4.500	—	OBSOLETE		6052744G27	6052744G38	3 5/8	6 1/4	5	8

INSULATORS

OUTDOOR BUS CLAMPS



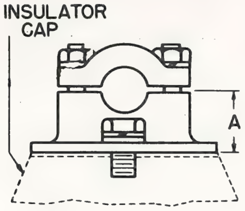
REAMED TO SIZE FITTINGS FOR ROUND CONDUCTORS

For attaching round bus or conductors to top or bottom of insulator units in assembly of outdoor bus supports.

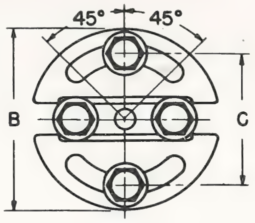
For materials used, see opposite page. For other details, see page 126.

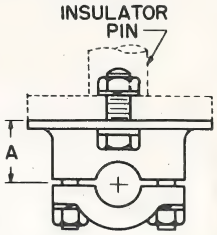
Spacers for slip-fit are included. For clamp-fit, remove them.

When ordering, please specify outside conductor diameter. When ordering for use with aluminum conductors, add suffix "A" to group number.



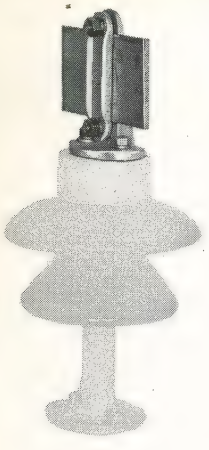
UPRIGHT

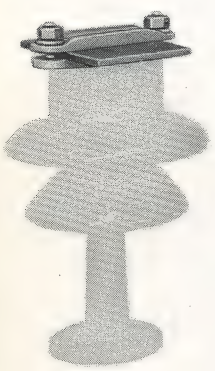


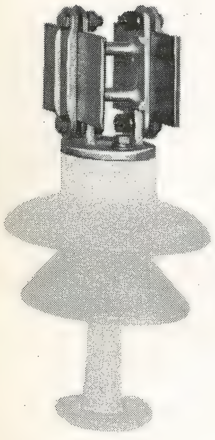


UNDERHUNG

	Conductor Size			Catalog Numbers		Dimensions—Inches			Ship. Wt. Lbs. Each
				All Nonmagnetic					
	I. P. S. Tubing Inches	Max. O. D. Inches	Bare Cable MCM	For Upright Insulators	For Underhung Insulators	A	B	C	
For insulators with 3 inch Bolt Circle	½	.840	500	6129744G1	6129744G6	1½	4¼	3	3
	¾	1.050	750	6129744G2	6129744G7	1¹⁹⁄₃₂	4¼	3	4
	1	1.315	1200	6129744G3	6129744G8	1²³⁄₃₂	4¼	3	4
	1¼	1.660	1500	6129744G4	5129744G9	1²⁹⁄₃₂	4¼	3	5
	1½	1.900	2000	6129744G5	6129744G10	2	4¼	3	5
	2	2.375	—	6129747G1	6129747G5	2¼	4¼	3	6
	2½	2.875	—	6129747G2	6129747G6	2½	4¼	3	6
	3	3.500	—	6129747G9	6129747G11	2⅞	4¼	3	7
	3½	4.000	—	6187174G1	6187174G5	3⅛	4¼	3	8
	4	4.500	—	6187174G2	6187174G6	3⅜	4¼	3	9
For insulators with 5 inch Bolt Circle	½	.840	500	6129746G1	6129746G6	1¹¹⁄₁₆	6¼	5	5
	¾	1.050	750	6129746G2	6129746G7	1²⁵⁄₃₂	6¼	5	6
	1	1.315	1250	6129746G3	6129746G8	1²⁹⁄₃₂	6¼	5	6
	1¼	1.660	1500	6129746G4	6129746G9	2³⁄₃₂	6¼	5	7
	1½	1.900	2000	6129746G5	6129746G10	2³⁄₁₆	6¼	5	8
	2	2.375	—	6129747G3	6129747G7	2⁷⁄₁₆	6¼	5	9
	2½	2.875	—	6129747G4	6129747G8	2¹¹⁄₁₆	6¼	5	10
	3	3.500	—	6129747G10	6129747G12	3	6¼	5	10
	3½	4.000	—	6187174G3	6187174G7	3¼	6¼	5	11
	4	4.500	—	6187174G4	6187174G8	3½	6¼	5	11







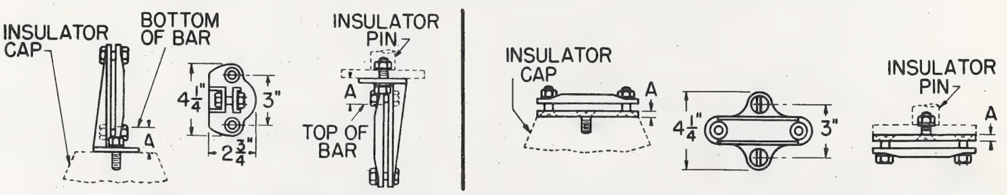
SWITCH AND BUS
OUTDOOR BUS CLAMPS

FOR RECTANGULAR BARS

For attaching rectangular bus bars or conductors to top or bottom of insulator units in assembly of outdoor bus supports. For other details, see page 126.

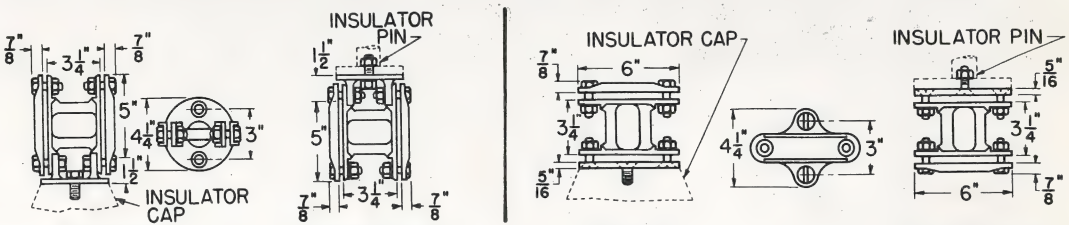
With the single-clamp type, a maximum of three ¼″ bars is recommended. With the two-clamp type, a maximum of six ¼″ bars is recommended, three per clamp with wide center fitting. Catalog number includes bolts for only one ¼″ bar per clamp. To obtain bolts of proper length, specify number of bars on your order. No spacers are included for mounting between bus laminations. When required, add ¼″ spacers.

FOR BARS ON EDGE **SINGLE CLAMP** **FOR FLAT BARS**


INSULATOR CAP
BOTTOM OF BAR
$4\frac{1}{4}$"
3"
$2\frac{3}{4}$"
A
INSULATOR PIN
A
TOP OF BAR
INSULATOR CAP
A
$4\frac{1}{4}$"
3"
INSULATOR PIN
A

Upright **Underhung** **Upright** **Underhung**

TWO CLAMP


$\frac{7}{8}$"
$3\frac{1}{4}$"
$\frac{7}{8}$"
5"
$4\frac{1}{4}$"
3"
$1\frac{1}{2}$"
INSULATOR CAP
INSULATOR PIN
$1\frac{1}{2}$"
5"
$\frac{7}{8}$"
$3\frac{1}{4}$"
$\frac{7}{8}$"
INSULATOR CAP
$\frac{7}{8}$"
6"
$3\frac{1}{4}$
$4\frac{1}{4}$"
3"
$\frac{5}{16}$"
INSULATOR PIN
$\frac{5}{16}$"
$3\frac{1}{4}$
6"
$\frac{7}{8}$"

Upright **Underhung** **Upright** **Underhung**

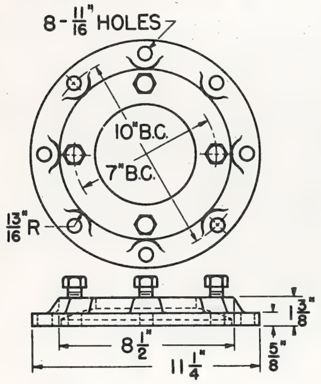
Type	Size of Conductor Bar Inches	Catalog Number				A In.	Approx. Ship. Wt. Lbs. Each
		Half—Nonmagnetic		All—Nonmagnetic			
		For Upright Insulators	For Underhung Insulators	For Upright Insulators	For Underhung Insulators		
Single Clamp		For Bars on Edge					
	2 x ¼	6159600G1	6159600G2	6159601G1	6159601G2	1½	4
	3 x ¼	6159600G3	6159600G4	6159601G3	6159601G4	1½	4
	4 x ¼	6159600G5	6159600G6	6159601G5	6159601G6	1½	4
		For Flat Bars					
	2 x ¼	6159602G1	6159602G2	6159603G1	6159603G2	½	4
	3 x ¼	6159602G3	6159602G4	6159603G3	6159603G4	½	4
	4 x ¼	6159602G5	6159602G6	6159603G5	6159603G6	½	4
Two Clamp		For Bars on Edge					
	4 x ¼	6159604G1	6159604G2	6159605G1	6159605G2	—	8
		For Flat Bars					
	4 x ¼	6159606G1	6159606G2	6159607G1	6159607G2	—	6

INSULATORS

OUTDOOR ADAPTERS AND SPACERS

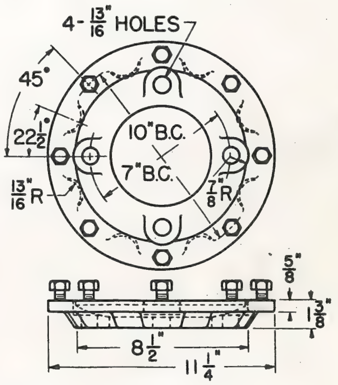
TRANSITION PLATES

For composite stacks of switch and bus insulators with seven and ten inch bolt circles.


8-$\frac{11}{16}$" HOLES
10" B.C.
7" B.C.
$\frac{13}{16}$" R
$1\frac{3}{8}$"
$8\frac{1}{2}$"
$11\frac{1}{4}$"
$\frac{5}{8}$"

10″ to 7″ transition plate used in insulator stack TR-33 for upright base mounting. Plate only—TR-151.

NO. 27472


4-$\frac{13}{16}$" HOLES
45°
$22\frac{1}{2}$°
10" B.C.
7" B.C.
$\frac{13}{16}$" R
$\frac{7}{8}$" R
$\frac{5}{8}$"
$1\frac{3}{8}$"
$8\frac{1}{2}$"
$11\frac{1}{4}$"

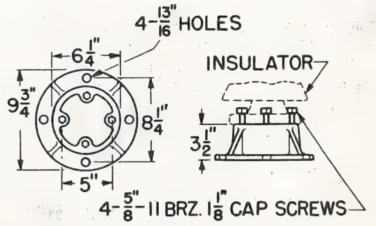
10″ to 7″ transition plate used in insulator stack TR-35 for underhung cap mounting. Plate only—TR-152.

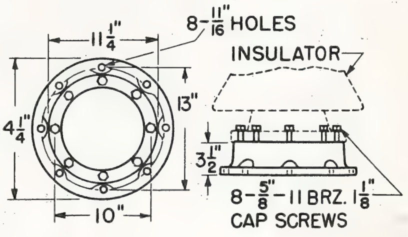
NO. 27473

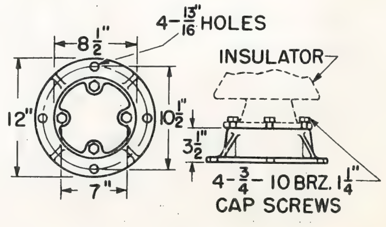
SUBBASE ADAPTERS AND SPACERS

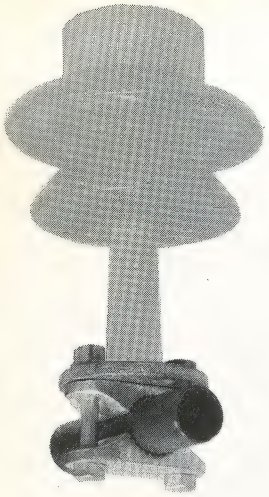
Used in mounting insulator stacks at the support end.

Catalog Number	Bolt Circle Size of Attachment	Ship. Weight Lbs.
7791	5-in. Top and $8\frac{1}{4}$-in. Bottom	$15\frac{1}{2}$
27422	10 in. Top and 13 in. Bottom	35
27423	7 in. Top and $10\frac{1}{2}$ in. Bottom	22


4-$\frac{13}{16}$" HOLES
$6\frac{1}{4}$"
INSULATOR
$9\frac{3}{4}$"
$8\frac{1}{4}$"
$3\frac{1}{2}$"
5"
4-$\frac{5}{8}$"-11 BRZ. $1\frac{1}{8}$" CAP SCREWS


8-$\frac{11}{16}$" HOLES
$11\frac{1}{4}$"
INSULATOR
13"
$14\frac{1}{4}$"
$3\frac{1}{2}$"
8-$\frac{5}{8}$"-11 BRZ. $1\frac{1}{8}$" CAP SCREWS
10"

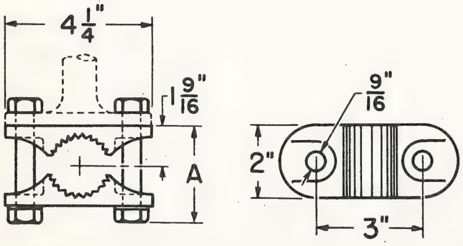

4-$\frac{13}{16}$" HOLES
$8\frac{1}{2}$"
INSULATOR
12"
$10\frac{1}{2}$"
$3\frac{1}{2}$"
4-$\frac{3}{4}$-10 BRZ. $1\frac{1}{4}$" CAP SCREWS
7"



SWITCH AND BUS
OUTDOOR ADAPTERS AND SPACERS

PIPE ADAPTERS

For mounting 3-inch bolt circle insulators on 1¼ or 2 inch pipe.

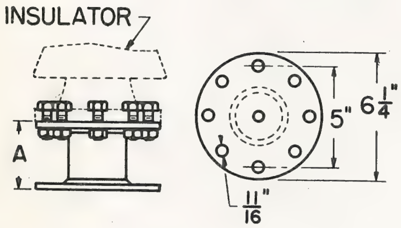


4 1/4"
1 9/16"
A
9/16"
2"
3"

Pipe Size Inches	Catalog Numbers		A Inches	Ship. Wt. Each Lb.
	For Upright or Horizontal Mounting	For Underhung Mounting		
1¼	**6026203 G1**	**6026203 G3**	3¼	3
2	**6026203 G2**	**6026203 G4**	4	3

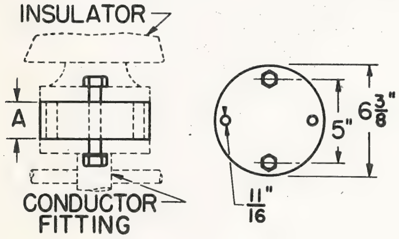
SPACERS

Used to obtain additional clearances.



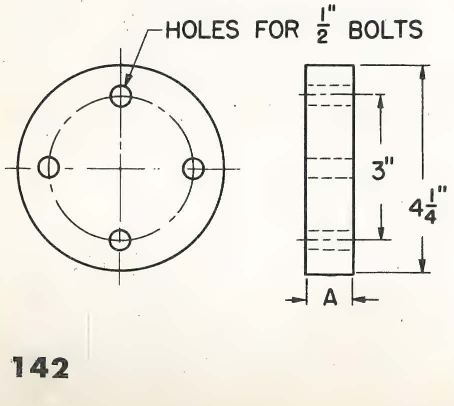
INSULATOR
A
5"
6 1/4"
11/16"

Fig. 1



INSULATOR
A
5"
6 3/8"
11/16"
CONDUCTOR FITTING

Fig. 2



HOLES FOR 1/2" BOLTS
3"
4 1/4"
A

Fig. 3

Catalog Number	Fig. No.	Bolt Circle Size of Attachment, Inches. Top and Bottom	A In.	Approx. Ship. Wt. Lbs.
6179647G1	1	5	3½	10
6026215G2	2	5	2¼	6
1883588PT5	3	3	1	1½
1883588PT11	3	3	2	3
1883588PT9	3	3	2½	4

INSULATORS

APPARATUS INSULATORS

COMPARATIVE CATALOG NUMBERS

TR. NO.	DESIGN*	LOCKE	O. B.	LAPP	PINCO	P. P.	THOMAS	VICTOR	WGHSE.
140	S	7785	31152	7290	735	69134	13074	729	545512
145	H	8888	33560	23319	750	6815	13057	706	678828
46	H	23070	34340	25554	891	6928	13279	707	1176130
141	S	23082	30575	9080	6095	—	—	730	1123729
142	S	23083	30577	9099	6097	—	—	731	845688
144	S	23109	33614	9500	—	—	—	739	—
205	P	29015	36310	27077	—	7315	—	—	—
208	P	29023	36314	25565	—	7323	—	—	—
210	P	29034	36318	9785	—	7334	—	—	—
214	P	29046	36322	25567	—	7346	—	—	—
216	P	29069	36330	9251	—	7369	—	—	—
202	P	29075	36375	10470	—	7307	—	—	—
13	S	29153	37746	27069	6046	68146	13846	705	1176230
1	S	29200	37708	27075	6075	67107	13808	740	968771
4	S	29250	37715	27073	6015	68115	13815	741	968768
7	S	29251	37723	25436	6023	68123	13823	742	968769
10	S	29455	37734	27071	6034	68134	13835	744	968770
147	S	29511	37769	24322	6069	68169	13869	724	1176190
53	H	30153	38750	30701	850	78146	—	—	—
41	H	30200	38710	30696	—	78107	—	—	—
44	H	30250	38720	30698	—	78115	—	—	1295355
49	H	30455	35190	30700	—	78134	—	—	1176131
58	E	32200	34749	—	—	—	—	—	—

* S—Standard Strength, H—High Strength, E—Extra High Strength, P—Station Post Type.

PROPOSED TDJ-58
DEVELOPED BY JOINT
EEI-NEMA COMMITTEE

PROPOSED EEI-NEMA

APPARATUS CAP AND PIN TYPE

1. SCOPE

1.1 These Standards cover high voltage, outdoor apparatus, cap and pin type insulators, made of wet-process porcelain, used in the transmission and distribution of electrical energy.

2. DEFINITIONS

2.1 See Section 2 of American Standards Association, "Insulator Tests," C29.1-1944, latest revision, for definition of terms.

2.2 In these standards the word "insulator" shall refer to a unit or to a stack of two or more units. In general, test clauses refer to single units except where an assembly of units is indicated on the data sheets.

2.3 The Technical Reference Numbers appearing on the data sheets are a widely used and recognized identification series for apparatus insulator units or stacks.

3. GENERAL

3.1 Standard insulators shall conform in all respects to the requirements hereinafter stated. The text, data sheets, and associated drawings supplement each other and all shall be considered as parts of these standards.

3.2 The data sheet drawings are type drawings and over-all dimensions are shown.

3.3 Manufacturer's drawings, if furnished, shall show the outline of the insulators together with all pertinent dimensions. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

4. MATERIAL

4.1 The insulators shall be made of good commercial grade wet-process porcelain.

4.2 The entire porcelain surface of the insulators that will be exposed after assembly shall be glazed. The standard color of the glaze shall be brown. The entire porcelain surface shall be relatively free from imperfections.

4.3 Ferrous metal parts shall be made of a good commercial grade of malleable iron or open hearth or electric furnace steel, galvanized in accordance with "ASTM Specifications for Zinc Coating (Hot Dip) on Iron and Steel Hardware," Publication No. A153-49, latest revision. Other metal parts shall be made of a material of suitable corrosion resistance and temper.

5. DIMENSIONS AND CHARACTERISTICS

5.1 Dimensions and characteristics shall be in accordance with the data sheets. Top and bottom holes shall be in line.

6. MARKING

6.1 Each insulator unit shall bear symbols identifying the manufacturer and the year of manufacture. The marking shall be legible and durable.

7. PACKING

7.1 Insulators shall be so packed as to prevent injury to them during transportation and handling. Insulators packed in containers conforming to all construction requirements of Consolidated Freight classifications as to bursting tests, size limit and gross weight shall be considered as adequately packed.

7.2 Each box or container shall be marked with the number of pieces contained therein, the catalogue number, or drawing number, or description of the contents and the manufacturer's name.

8. MANUFACTURER'S PRODUCTION SAMPLING AND TESTS

8.1 The manufacturer shall make adequate tests to determine that insulators manufactured in accordance with these standards will meet the requirements thereof.

9. SAMPLING, INSPECTION AND TESTS

9.1 **General**—Substantial test experience, over a long period of time, indicates that a total of ½ of 1% of the number of insulators in a lot is sufficient to establish characteristics demonstrable by destructive tests.

9.2 **Dimensions**—Three insulators shall be selected at random from the lot and their dimensions checked against the dimensions on the manufacturer's drawing. Failure of more than one of these insulators to conform, within manufacturing tolerances, to the dimensions on this drawing shall constitute failure of the lot to meet this standard.

9.3 **Design Tests**—Certified test data on insulators of existing design shall be regarded as equivalent to actual design tests. Design tests on insulators of new design shall be made in accordance with paragraphs 9.3.1 through 9.3.8.

9.3.1 **Low-Frequency Dry-Withstand**—Three insulators shall be selected at random and tested in accordance with paragraph 4.2.9 of American Standards Association C29.1-1944, latest revision. Failure of any insulator to meet the rated dry-withstand value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.2 **Low-Frequency Dry-Flashover**—Three insulators shall be selected at random and tested in accordance with Section 4.1 of American Standards Association C29.1-1944, latest revision. Failure of the average dry-flashover value of the three insulators to equal or exceed 95% of the rated dry-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.3 **Low-Frequency Wet-Withstand**—Three insulators shall be selected at random and tested in accordance with paragraph 4.2.10 of American Standards Association C29.1-1944, latest revision. Failure of any insulator to meet the rated wet-withstand value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.4 **Low-Frequency Wet-Flashover**—Three insulators shall be selected at random and tested in accordance with Section 4.2 of American Standards Association C29.1-1944, latest revision. Failure of the average wet-flashover value of the three insulators to equal or exceed 90% of the rated wet-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.5 **Critical Impulse Flashover—Positive and Negative**—Three insulators shall be selected at random for the critical-impulse flashover, positive, and three for the critical-impulse flashover, negative, and tested in accordance with Section 4.3 of American Standards Association C29.1-1944, latest revision. Failure of the average critical-impulse flashover value of the three insulators to equal or exceed 92% of the rated critical-impulse flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.6 **Impulse Withstand**—Three insulators shall be selected at random and tested in accordance with Section 4.4 of American Standards Association C29.1-1944, latest revision. Failure of any insulator to meet the rated impulse-withstand value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.7 **Radio-Influence Voltage**—Five insulators shall be selected at random and tested in accordance with Section 4.5 of American Standards Association C29.1-1944, latest revision. If one or more insulators fail to meet the requirements given on the applicable data sheet, five additional insulators shall be selected at random and tested. Failure of one or more of these additional insulators shall constitute failure to meet this standard.

9.3.8 **Compression Strength**—Three insulators shall be selected at random and tested in accordance with paragraph 5.1.4.4 of American Standard Association C29.1-1944, latest revision. Failure of the average strength of the three insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85% of that strength requirement, shall constitute failure to meet this standard.

9.4 **Quality Conformance Tests**—Tests outlined in paragraphs 9.4.1 through 9.4.8 are for use when witnessed or certified tests are required to demonstrate conformity with these standards.

9.4.1 **Visual**—Conformity with paragraph 4.2 may be determined by visual inspection. All insulators not conforming to paragraph 4.2 fail to meet this standard.

9.4.2 **Porosity**—Test specimens shall be selected from insulators destroyed in other tests and tested in accordance with Section 5.4 of American Standards Association C29.1-1944, latest revision. Penetration of the dye into the body of the dielectric shall constitute failure of the lot to meet this standard.

9.4.3 **Galvanizing**—Two pieces representative of each type of hardware used with the insulators shall be selected at random before assembly and tested in accordance with Section 6.1 of American Standards Association C29.1-1944, latest revision. If one specimen fails to withstand six (except for cap screws, bolts, and nuts, only four required) one-minute copper sulphate dips ("ASTM Method of Test for Uniformity of Coating by the Preece Test (Copper Sulphate Dip) on Zinc-coated (Galvanized) Iron or Steel Articles," Publication No. A239-41, latest revision), three additional pieces of the same type of hardware shall be selected at random from the same lot and tested. Failure of more than one specimen, from the first sample or from the first and second sample combined, to withstand the required number of dips, shall constitute failure of the lot to meet this standard.

9.4.4 **Thermal Shock**—Three insulators shall be selected at random and tested in accordance with Section 5.5 of American Standards Association C29.1-1944, latest revision. If one insulator fails, three additional insulators shall be selected at random from the same lot and tested. Failure of more than one insulator from the first sample or from the first and second sample combined, shall constitute failure of the lot to meet this standard.

9.4.5 **Cantilever Strength**—Three insulators shall be selected at random and tested in accordance with paragraph 5.1.4.1 of American Standards Association C29.1-1944, latest revision. Failure of the average strength of the three insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85% of that strength requirement, shall constitute failure of the lot to meet this standard.

9.4.6 **Torsional Strength**—Three insulators shall be selected at random and tested in accordance with paragraph 5.1.4.2 of American Standards Association C29.1-1944, latest revision. Failure of the average strength of the three insulators to meet the strength requirements given on the applicable data sheet or failure of any one insulator to equal 85% of that strength requirement, shall constitute failure of the lot to meet this standard.

9.4.7 **Tensile Strength**—Three insulators shall be selected at random and tested in accordance with paragraph 5.1.4.3 of American Standards Association C29.1-1944, latest revision. Failure of the average strength of the three insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85% of that strength requirement, shall constitute failure of the lot to meet this standard.

9.4.8 **Puncture**—Three assembled insulators shall be selected at random and tested in accordance with Section 4.7 of American Standards Association C29.1-1944, latest revision. The oil used in this test shall have a breakdown voltage of not less than 12.5 KV when measured in accordance with paragraphs 22, 23 and 24 of "ASTM Methods of Testing Electrical Insulating Oils," Publication No. D117-50, latest revision. If the average puncture voltage of the three insulators fails to meet the requirement given on the applicable data sheet or if the per cent average variation exceeds fifteen, this shall constitute failure of the lot to meet this standard.

9.5 **Routine Tests**

9.5.1 **Tension Proof**—Each insulator unit shall be tested in tension in accordance with paragraph 7.2.2 of American Standards Association C29.1-1944, latest revision. The load applied shall be that shown on the applicable data sheet. All units which fail do not meet this standard.

9.5.2 **Flashover**—Each insulator unit shall be subjected to a routine flashover test in accordance with paragraph 7.1.1 or 7.1.2 of American Standards Association C29.1-1944, latest revision. All units which puncture fail to meet this standard.

PROPOSED TDJ-58
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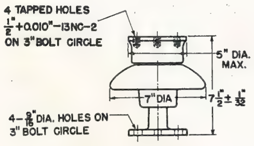
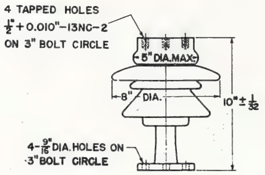
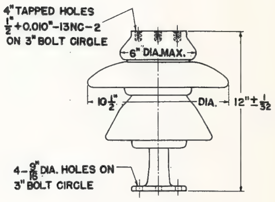
APPARATUS CAP AND PIN TYPE (CONT.)


4 TAPPED HOLES
1/2"+0.010"-13NC-2
ON 3" BOLT CIRCLE
5" DIA. MAX.
7" DIA
7 1/2" ± 1/32"
4-9/16" DIA. HOLES ON
3" BOLT CIRCLE

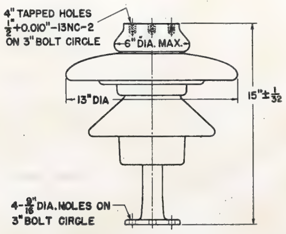
T. R. No. 1


4 TAPPED HOLES
1/2"+0.010"-13NC-2
ON 3" BOLT CIRCLE
5" DIA.MAX.
8" DIA.
10" ± 1/32
4-9/16" DIA. HOLES ON
3" BOLT CIRCLE

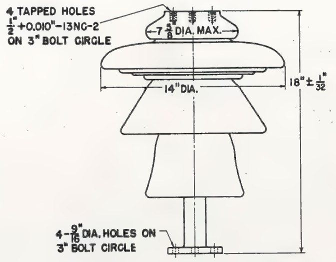
T. R. No. 4


4" TAPPED HOLES
1/2"+0.010"-13NC-2
ON 3" BOLT CIRCLE
6" DIA.MAX.
10 1/2" DIA.
12" ± 1/32
4-9/16" DIA. HOLES ON
3" BOLT CIRCLE

T. R. No. 7


4" TAPPED HOLES
1/2"+0.010"-13NC-2
ON 3" BOLT CIRCLE
6" DIA. MAX.
13" DIA
15" ± 1/32
4-9/16" DIA. HOLES ON
3" BOLT CIRCLE

T. R. No. 10


4 TAPPED HOLES
1/2"+0.010"-13NC-2
ON 3" BOLT CIRCLE
7 5/8" DIA. MAX.
14" DIA.
18" ± 1/32"
4-9/16" DIA. HOLES ON
3" BOLT CIRCLE

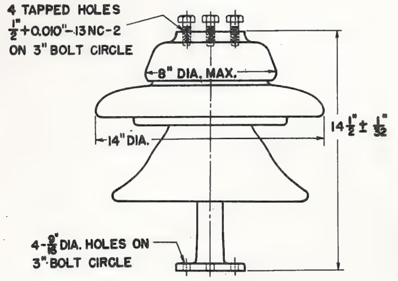
T. R. No. 13

Characteristics	Rating					Paragraph In Pub. No. C29.1-1944
TECHNICAL REFERENCE NUMBER	1	4	7	10	13	
DIMENSIONS						
Leakage Distance, Inches	7½	12	20	28	36	2.6.1
Dry Arcing Distance, Inches	5¼	7¼	9½	14	17	2.6.2
MECHANICAL VALUES						
Cantilever Strength—Upright, Pounds	2000	2000	2000	2000	2000	5.1.4.1
Cantilever Strength—Underhung, Pounds	1000	1000	1000	1000	1000	5.1.4.1
Tensile Strength, Pounds	5000	5000	5000	7000	8000	5.1.4.3
Torsional Strength, Inch-Pounds	6000	7000	8000	10000	12000	5.1.4.2
Compression Strength, Pounds	10000	10000	10000	15000	15000	5.1.4.4
Tension Proof Test Load, Pounds	1250	1250	1250	1750	2000	7.2.2
ELECTRICAL VALUES						
Low-frequency Flashover—Dry, Kv	60	85	110	145	170	4.1
Low-frequency Flashover—Wet, Kv	40	55	75	100	125	4.2
Impulse Flashover—Positive, Kv	105	125	170	225	280	4.3
Impulse Flashover—Negative, Kv	120	200	250	290	340	4.3
Low-frequency Withstand—Dry, Kv	35	50	70	95	120	4.2.9
Low-frequency Withstand—Wet, Kv	30	45	60	80	100	4.2.10
Impulse Withstand, Kv	95	110	150	200	250	4.4
Low-frequency Puncture, Kv	80	115	145	195	225	4.7
RADIO INFLUENCE VOLTAGE DATA						
Low-frequency Test Voltage, Kv	5	10	15	22	30	4.5
Maximum R.I.V., Microvolts at 1000 Kc	50	50	100	100	200	4.5

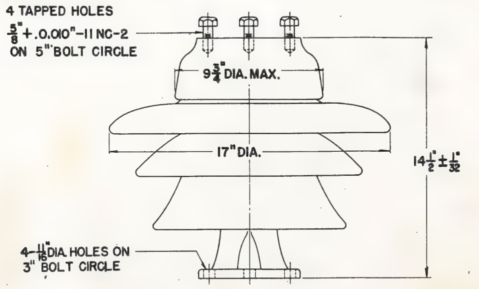
NOTE—If high resistance coatings are applied to the insulator, such coatings shall be considered as effective leakage surfaces and distance over them shall be included in the leakage distance.

STANDARDS

FOR WET PROCESS PORCELAIN INSULATORS


4 TAPPED HOLES
$\frac{1}{2}$"+0.010"-13NC-2
ON 3" BOLT CIRCLE
8" DIA. MAX.
14" DIA.
14$\frac{1}{2}$" ± $\frac{1}{32}$"
4-$\frac{9}{16}$" DIA. HOLES ON
3" BOLT CIRCLE

T. R. No. 147


4 TAPPED HOLES
$\frac{5}{8}$"+.0.010"-11NC-2
ON 5" BOLT CIRCLE
9$\frac{3}{4}$" DIA. MAX.
17" DIA.
14$\frac{1}{2}$" ± $\frac{1}{32}$"
4-$\frac{11}{16}$" DIA. HOLES ON
3" BOLT CIRCLE

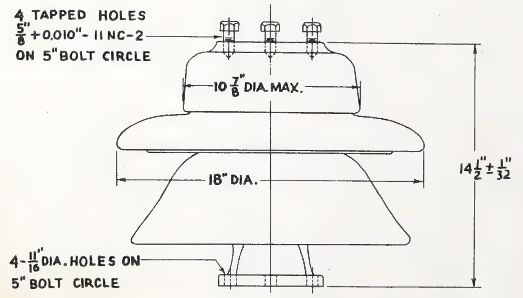
T. R. No. 140

Characteristics	Rating								Paragraph In Pub. No. C29.1-1944
NUMBER OF UNITS PER STACK	1	2	1	2	3	4	5	6	
TECHNICAL REFERENCE NUMBER	147	16	140	56	19	25	126	128	
DIMENSIONS									
Leakage Distance, Inches	26	52	33	66	99	132	165	198	2.6.1
Dry Arcing Distance, Inches	13¾	28	14¾	29	44	58	73	87	2.6.2
MECHANICAL VALUES									
Cantilever Strength—Upright, Pounds	3000	1500	7000	3000	1700	1200	910	750	5.1.4.1
Cantilever Strength—Underhung, Pounds	2000	1000	4000	2350	1470	1070	840	700	5.1.4.1
Tensile Strength, Pounds	12000		20000						5.1.4.3
Torsional Strength, Inch-Pounds	15000		40000						5.1.4.2
Compression Strength, Pounds	25000		60000						5.1.4.4
Tension Proof Test Load, Pounds	2000		2000						7.2.2
ELECTRICAL VALUES						See Note II			
Low-frequency Flashover—Dry, Kv	140	235	160	280	385	485	575	660	4.1
Low-frequency Flashover—Wet, Kv	85	180	95	190	285	380	475	570	4.2
Impulse Flashover—Positive, Kv	210	390	235	410	610	810	1010	1210	4.3
Impulse Flashover—Negative, Kv	260	475	290	540	780	1020	1240	1450	4.3
Low-frequency Withstand—Dry, Kv	95	175	115	205	280	385	465	545	4.2.9
Low-frequency Withstand—Wet, Kv	70	145	75	160	230	315	385	455	4.2.10
Impulse Withstand, Kv	190	350	210	350	550	750	900	1050	4.4
Low-frequency Puncture, Kv	195		215						4.7
RADIO INFLUENCE VOLTAGE DATA									
Low-frequency Test Voltage, Kv	22	44	22	44	73	103	125	146	4.5
Maximum R.I.V. Microvolts at 1000 Kc	100	200	100	200	200	500	500	500	4.5

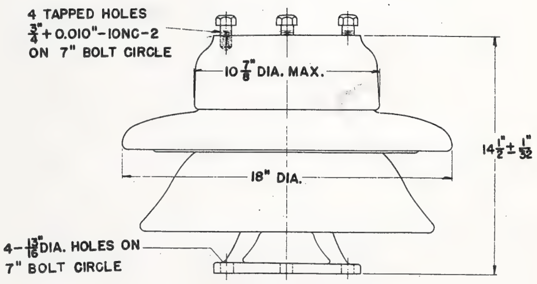
NOTE I—If high resistance coatings are applied to the insulator, such coatings shall be considered as effective leakage surfaces, and distance over them shall be included in the leakage distance.

NOTE II—Flashover and withstand ratings are predicated on the use of a sub-base of 3½" height, or its equivalent.

APPARATUS CAP AND PIN TYPE (CONT.)


4 TAPPED HOLES
5/8"+0.010"-11NC-2
ON 5" BOLT CIRCLE
10 7/8" DIA. MAX.
18" DIA.
14 1/2" ± 1/32"
4-11/16" DIA. HOLES ON
5" BOLT CIRCLE

T. R. No. 141


4 TAPPED HOLES
3/4"+0.010"-10NC-2
ON 7" BOLT CIRCLE
10 7/8" DIA. MAX.
18" DIA.
14 1/2" ± 1/32"
4-13/16" DIA. HOLES ON
7" BOLT CIRCLE

T. R. No. 142

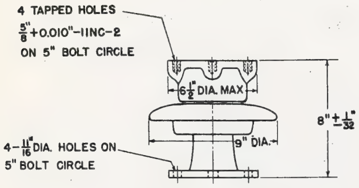
Characteristics	Rating								Paragraph In Pub. No. C29.1-1944
NUMBER OF UNITS PER STACK	1	4	5	6	1	6	7	8	
TECHNICAL REFERENCE NUMBER	141	123	27	28	142	129	133	135	
DIMENSIONS									
Leakage Distance, Inches	33	132	165	198	33	198	231	264	2.6.1
Dry Arcing Distance, Inches	16	59	74	88	16	88	103	117	2.6.2
MECHANICAL VALUES									
Cantilever Strength—Upright—Pounds	10000	2000	1450	1170	10000	1170	1000	900	5.1.4.1
Cantilever Strength—Underhung—Pounds	6000	1750	1350	1100	6000	1100	950	860	5.1.4.1
Tensile Strength, Pounds	25000				25000				5.1.4.3
Torsional Strength, Inch-Pounds	90000				90000				5.1.4.2
Compression Strength, Pounds	75000				75000				5.1.4.4
Tension Proof Test Load, Pounds	2000				2000				7.2.2
ELECTRICAL VALUES									
Low-frequency Flashover—Dry, Kv	160	485	575	660	160	660	745	830	4.1
Low-frequency Flashover—Wet, Kv	95	380	475	570	95	570	660	740	4.2
Impulse Flashover—Positive, Kv	235	810	1010	1210	235	1210	1410	1610	4.3
Impulse Flashover—Negative, Kv	290	1020	1240	1450	290	1450	1650	1850	4.3
Low-frequency Withstand—Dry, Kv	115	385	465	545	115	545	610	680	4.2.9
Low-frequency Withstand—Wet, Kv	75	315	385	455	75	455	525	590	4.2.10
Impulse Withstand, Kv	210	750	900	1050	210	1050	1300	1470	4.4
Low-frequency Puncture, Kv	215				215				4.7
RADIO INFLUENCE VOLTAGE DATA									
Low-frequency Test Voltage, Kv	22	103	125	146	22	146	180	210	4.5
Maximum R.I.V., Microvolts at 1000 Kilocycles	100	500	500	500	100	500	1000	1000	4.5

NOTE I—If high resistance coatings are applied to the insulator, such coatings shall be considered as effective leakage surfaces, and distance over them shall be included in the leakage distance.

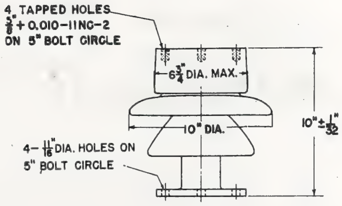
NOTE II—Flashover and withstand ratings are predicated on the use of a sub-base of 3½" height, or its equivalent.

STANDARDS

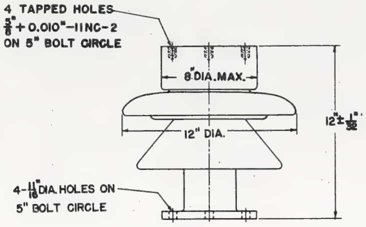
FOR WET PROCESS PORCELAIN INSULATORS


4 TAPPED HOLES
5/8"+0.010"-11NC-2
ON 5" BOLT CIRCLE
6 1/2" DIA. MAX
8"±1/32"
9" DIA.
4-11/16" DIA. HOLES ON
5" BOLT CIRCLE

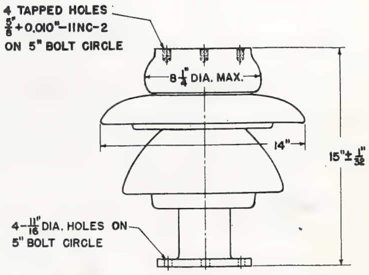
T. R. No. 41


4 TAPPED HOLES
5/8"+0.010-11NC-2
ON 5" BOLT CIRCLE
6 3/4" DIA. MAX.
10" DIA.
10"±1/32"
4-11/16" DIA. HOLES ON
5" BOLT CIRCLE

T. R. No. 44


4 TAPPED HOLES
5/8"+0.010"-11NC-2
ON 5" BOLT CIRCLE
8" DIA. MAX.
12" DIA.
12"±1/32"
4-11/16" DIA. HOLES ON
5" BOLT CIRCLE

T. R. No. 46


4 TAPPED HOLES
5/8"+0.010"-11NC-2
ON 5" BOLT CIRCLE
8 1/4" DIA. MAX.
14"
15"±1/32"
4-11/16" DIA. HOLES ON
5" BOLT CIRCLE

T. R. No. 49

Characteristics	Rating				Paragraph In Pub. No. C29.1-1944
TECHNICAL REFERENCE NUMBER	41	44	46	49	
DIMENSIONS					
Leakage Distance, Inches	8	14	18	28	2.6.1
Dry Arcing Distance, Inches	5½	7½	10½	13½	2.6.2
MECHANICAL VALUES					
Cantilever Strength—Upright, Pounds	4000	4000	4000	4000	5.1.4.1
Cantilever Strength—Underhung, Pounds	3000	3000	3000	3000	5.1.4.1
Tensile Strength, Pounds	10000	10000	10000	14000	5.1.4.3
Torsional Strength, Inch-Pounds	12000	14000	16000	20000	5.1.4.2
Compression Strength, Pounds	20000	20000	20000	30000	5.1.4.4
Tension Proof Test Load, Pounds	2000	2000	2000	2000	7.2.2
ELECTRICAL VALUES					
Low-frequency Flashover—Dry, Kv	60	85	110	145	4.1
Low-frequency Flashover—Wet, Kv	40	55	75	100	4.2
Impulse Flashover—Positive, Kv	105	125	170	225	4.3
Impulse Flashover—Negative, Kv	120	200	250	290	4.3
Low-frequency Withstand—Dry, Kv	35	50	70	95	4.2.9
Low-frequency Withstand—Wet, Kv	30	45	60	80	4.2.10
Impulse Withstand, Kv	95	110	150	200	4.4
Low Frequency Puncture, Kv	90	115	145	195	4.7
RADIO INFLUENCE VOLTAGE DATA					
Low Frequency Test Voltage, Kv	5	10	15	22	4.5
Maximum R.I.V., Microvolts at 1000 Kc	50	50	100	100	4.5

NOTE—If high resistance coatings are applied to the insulator, such coatings shall be considered as effective leakage surfaces and distance over them shall be included in the leakage distance.

PROPOSED TDJ-59
DEVELOPED BY JOINT
EEI-NEMA COMMITTEE

PROPOSED EEI-NEMA

APPARATUS POST TYPE

1. SCOPE

1.1 These standards cover high voltage, outdoor apparatus, post type insulators, made of wet-process porcelain, used in the transmission and distribution of electrical energy.

2. DEFINITIONS

2.1 See Section 2 of American Standards Association, "Insulator Tests," C29.1-1944, latest revision, for definition of terms (Page 204).

2.2 In these standards the word "insulator" shall refer to a unit or to a stack of two or more units. In general, test clauses refer to single units except where an assembly of units is indicated on the data sheets.

2.3 The Technical Reference Numbers appearing on the data sheets are a widely used and recognized identification series for apparatus insulator units or stacks.

3. GENERAL

3.1 Standard insulators shall conform in all respects to the requirements hereinafter stated. The text, data sheets, and associated drawings supplement each other and all shall be considered as parts of these standards.

3.2 The data sheet drawings are type drawings and over-all dimensions are shown.

3.3 Manufacturer's drawings, if furnished, shall show the outline of the insulators together with all pertinent dimensions. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

4. MATERIAL

4.1 The insulators shall be made of good commercial grade wet-process porcelain.

4.2 The entire porcelain surface of the insulators that will be exposed after assembly shall be glazed. The standard color of the glaze shall be brown. The entire porcelain surface shall be relatively free from imperfections.

4.3 Ferrous metal parts shall be made of a good commercial grade of malleable iron or open hearth or electric furnace steel, galvanized in accordance with "ASTM Specifications for Zinc Coating (Hot Dip) on Iron and Steel Hardware,"* Publication No. A153-49, latest revision. Other metal parts shall be made of a material of suitable corrosion resistance and temper.

5. DIMENSIONS AND CHARACTERISTICS

5.1 Dimensions and characteristics shall be in accordance with the data sheets. Top and bottom holes shall be in line.

6. MARKING

6.1 Each insulator unit shall bear symbols identifying the manufacturer and the year of manufacture. The marking shall be legible and durable.

7. PACKING

7.1 Insulators shall be so packed as to prevent injury to them during transportation and handling. Insulators packed in containers conforming to all construction requirements of Consolidated Freight classifications as to bursting tests, size limit and gross weight shall be considered as adequately packed.

7.2 Each box or container shall be marked with the number of pieces contained therein, the catalogue number, or drawing number, or description of the contents and the manufacturer's name.

8. MANUFACTURER'S PRODUCTION SAMPLING AND TESTS

8.1 The manufacturer shall make adequate tests to determine that insulators manufactured in accordance with these standards will meet the requirements thereof.

9. SAMPLING, INSPECTION AND TESTS

9.1 **General.** Substantial test experience, over a long period of time, indicates that a total of ½ of 1% of the number of insulators in a lot is sufficient to establish characteristics demonstrable by destructive tests.

9.2 **Dimensions.** Three insulators shall be selected at random from the lot and their dimensions checked against the dimensions on the manufacturer's drawing. Failure of more than one of these insulators to conform, within manufacturing tolerances, to the dimensions on this drawing shall constitute failure of the lot to meet this standard.

9.3 **Design Tests.** Certified test data on insulators of existing design shall be regarded as equivalent to actual design tests. Design tests on insulators of new design shall be made in accordance with paragraphs 9.3.1 through 9.3.8.

9.3.1 **Low-Frequency Dry-Withstand.** Three insulators shall be selected at random and tested in accordance with paragraph 4.2.9 of American Standards Association C29.1-1944, latest revision. Failure of any insulator to meet the rated dry-withstand value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.2 **Low-Frequency Dry-Flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.1 of American Standards Association C29.1-1944, latest revision. Failure of the average dry-flashover value of the three insulators to equal or exceed 95% of the rated dry-flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.3 **Low-Frequency Wet-Withstand.** Three insulators shall be selected at random and tested in accordance with paragraph 4.2.10 of American Standards Association C29.1-1944, latest revision. Failure of any insulator to meet the rated wet-withstand value, as given on the applicable data sheet, shall constitute failure to meet this standard.

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*Copies are available from the American Society for Testing Materials. 1916 Race Street, Philadelphia 3, Pa.

9.3.4 **Low-Frequency Wet-Flashover.** Three insulators shall be selected at random and tested in accordance with Section 4.2 of American Standards Association C29.1-1944, latest revision. Failure of the average wet-flashover value of the three insulators to equal or exceed 90% of the rated wet-flashover values, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.5 **Critical-Impulse Flashover — Positive and Negative.** Three insulators shall be selected at random for the critical-impulse flashover, positive, and three for the critical-impulse flashover, negative, and tested in accordance with Section 4.3 of American Standards Association C29.1-1944, latest revision. Failure of the average critical-impulse flashover value of the three insulators to equal or exceed 92% of the rated critical-impulse flashover value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.6 **Impulse-Withstand.** Three insulators shall be selected at random and tested in accordance with Section 4.4 of American Standards Association C29.1-1944, latest revision. Failure of any insulator to meet the rated impulse-withstand value, as given on the applicable data sheet, shall constitute failure to meet this standard.

9.3.7 **Radio-Influence Voltage.** Five insulators shall be selected at random and tested in accordance with Section 4.5 of American Standards Association C29.1-1944, latest revision. If one or more insulators fail to meet the requirements given on the applicable data sheet, five additional insulators shall be selected at random and tested. Failure of one or more of these additional insulators shall constitute failure to meet this standard.

9.3.8 **Compression Strength.** Three insulators shall be selected at random and tested in accordance with paragraph 4.1.4.4 of American Standards Association C29.1-1944, latest revision. Failure of the average strength of the three insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85% of that strength requirement, shall constitute failure to meet this standard.

9.4 **Quality Conformance Tests.** Tests outlined in paragraphs 9.4.1 through 9.4.7 are for use when witnessed or certified tests are required to demonstrate conformity with these standards.

9.4.1 **Visual.** Conformity with paragraph 4.2 may be determined by visual inspection. All insulators not conforming to paragraph 4.2 fail to meet this standard.

9.4.2 **Porosity.** Test specimens shall be selected from insulators destroyed in other tests and tested in accordance with Section 5.4 of American Standards Association C29.1-1944, latest revision. Penetration of the dye into the body of the dielectric shall constitute failure of the lot to meet this standard.

9.4.3 **Galvanizing.** Two pieces representative of each type of hardware used with the insulators shall be selected at random before assembly and tested in accordance with Section 6.1 of American Standards Association C29.1-1944, latest revision. If one specimen fails to withstand six (except for cap screws, bolts, and nuts, only four required) one-minute copper sulphate dips ("ASTM Method of Test for Uniformity of Coating by the Preece Test (Copper Sulphate Dip) on Zinc-coated (Galvanized) Iron or Steel Articles," Publication No. A239-41, latest revision), three additional pieces of the same type of hardware shall be selected at random from the same lot and tested. Failure of more than one specimen, from the first sample or from the first and second sample combined, to withstand the required number of dips, shall constitute failure of the lot to meet this standard.

9.4.4 **Thermal Shock.** Three insulators shall be selected at random and tested in accordance with Section 5.5 of American Standards Association C29.1-1944, latest revision. If one insulator fails, three additional insulators shall be selected at random from the same lot and tested. Failure of more than one insulator from the first sample or from the first and second sample combined, shall constitute failure of the lot to meet this standard.

9.4.5 **Cantilever Strength.** Three insulators shall be selected at random and tested in accordance with paragraph 5.1.4.1 of American Standards Association C29.1-1944, latest revision. Failure of the average strength of the three insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85% of that strength requirement, shall constitute failure of the lot to meet this standard.

9.4.6 **Torsional Strength.** Three insulators shall be selected at random and tested in accordance with paragraph 5.1.4.2 of American Standards Association C29.1-1944, latest revision. Failure of the average strength of the three insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85% of that strength requirement, shall constitute failure of the lot to meet this standard.

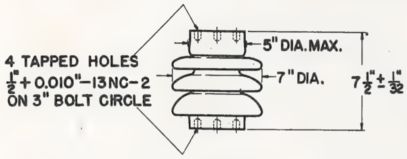
9.4.7 **Tensile Strength.** Three insulators shall be selected at random and tested in accordance with paragraph 5.1.4.3 of American Standards Association C29.1-1944, latest revision. Failure of the average strength of the three insulators to meet the strength requirement given on the applicable data sheet or failure of any one insulator to equal 85% of that strength requirement, shall constitute failure of the lot to meet this standard.

9.5 Routine Tests

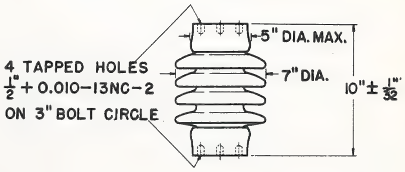
9.5.1 **Flashover.** Each insulator unit shall be subjected to a routine flashover test before assembly, in accordance with paragraph 7.1.1 or 7.1.2 of American Standards Association C29.1-1944, latest revision. For this test, an electrode shall be placed on each side of and adjacent to the porcelain barrier. All units which puncture fail to meet this standard.

9.5.2 **Tension Proof.** Each insulator unit shall be tested in tension in accordance with paragraph 7.2.2 of American Standards Association C29.1-1944, latest revision, except that this test shall follow rather than precede the routine flashover test, paragraph 9.5.1. The load applied shall be that shown on the applicable data sheet. All units which fail do not meet this standard.

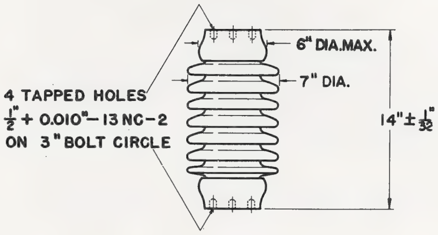
APPARATUS POST TYPE (CONT.)


4 TAPPED HOLES
1/2" + 0.010"–13NC–2
ON 3" BOLT CIRCLE
5" DIA. MAX.
7" DIA.
7 1/2" ± 1/32"

T. R. No. 202


4 TAPPED HOLES
1/2" + 0.010–13NC–2
ON 3" BOLT CIRCLE
5" DIA. MAX.
7" DIA.
10" ± 1/32"

T. R. No. 205

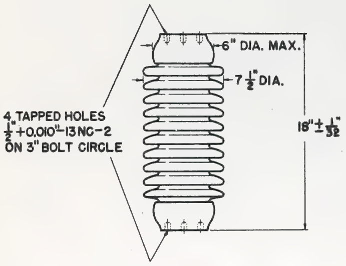

4 TAPPED HOLES
1/2" + 0.010"–13NC–2
ON 3" BOLT CIRCLE
6" DIA. MAX.
7" DIA.
14" ± 1/32"

T. R. No. 208

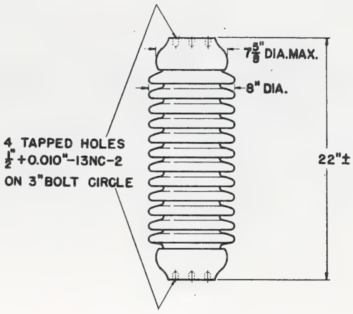
Characteristics	Rating			Paragraph In Pub. No. C29.1-1944
TECHNICAL REFERENCE NUMBER	202	205	208	
DIMENSIONS				
Leakage Distance, Inches	10½	15½	24	2.6.1
Dry Arcing Distance, Inches	6	7¼	10½	2.6.2
MECHANICAL VALUES				
Cantilever Strength, Pounds	2000	2000	2000	5.1.4.1
Tensile Strength, Pounds	5000	5000	5000	5.1.4.3
Torsional Strength, Inch-Pounds	6000	7000	8000	5.1.4.2
Compression Strength, Pounds	10000	10000	10000	5.1.4.4
Tension Proof Test Load, Pounds	1250	1250	1250	7.2.2
ELECTRICAL VALUES				
Low-frequency Flashover—Dry, Kv	60	85	110	4.1
Low-frequency Flashover—Wet, Kv	40	55	75	4.2
Impulse Flashover—Positive, Kv	105	125	170	4.3
Impulse Flashover—Negative, Kv	120	200	250	4.3
Low-frequency Withstand—Dry, Kv	35	50	70	4.2.9
Low-frequency Withstand—Wet, Kv	30	45	60	4.2.10
Impulse Withstand, Kv	95	110	150	4.4
RADIO INFLUENCE VOLTAGE DATA				
Low-frequency Test Voltage, Kv	5	10	15	4.5
Maximum R.I.V., Microvolts at 1000 Kc	50	50	100	4.5

STANDARDS

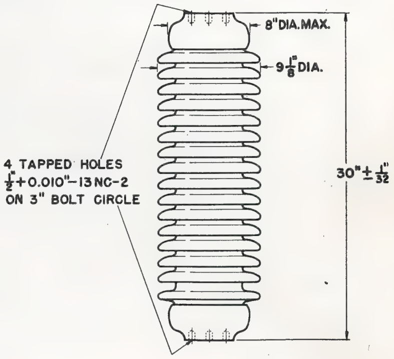
FOR WET PROCESS PORCELAIN INSULATORS


6" DIA. MAX.
7 1/2" DIA.
4 TAPPED HOLES
1/2" +0.010"-13NC-2
ON 3" BOLT CIRCLE
18" ± 1/32"

T. R. No. 210


7 5/8" DIA. MAX.
8" DIA.
4 TAPPED HOLES
1/2" +0.010"-13NC-2
ON 3" BOLT CIRCLE
22" ± 1/32"

T. R. No. 214


8" DIA. MAX.
9 1/8" DIA.
4 TAPPED HOLES
1/2" +0.010"-13NC-2
ON 3" BOLT CIRCLE
30" ± 1/32"

T. R. No. 216

Characteristics	Rating			Paragraph In Pub. No. C29.1-1944
TECHNICAL REFERENCE NUMBER	210	214	216	
DIMENSIONS				
Leakage Distance, Inches	37	43	72	2.6.1
Dry Arcing Distance, Inches	14½	17	26	2.6.2
MECHANICAL VALUES				
Cantilever Strength, Pounds	2000	2000	1500	5.1.4.1
Tensile Strength, Pounds	7000	8000	12000	5.1.4.3
Torsional Strength, Inch-Pounds	10000	12000	15000	5.1.4.2
Compression Strength, Pounds	15000	15000	25000	5.1.4.4
Tension Proof Test Load, Pounds	1750	2000	2000	7.2.2
ELECTRICAL VALUES				
Low-frequency Flashover—Dry, Kv	145	170	235	4.1
Low-frequency Flashover—Wet, Kv	100	125	180	4.2
Impulse Flashover—Positive, Kv	225	280	390	4.3
Impulse Flashover—Negative, Kv	290	340	475	4.3
Low-frequency Withstand—Dry, Kv	95	120	175	4.2.9
Low-frequency Withstand—Wet, Kv	80	100	145	4.2.10
Impulse Withstand, Kv	200	250	350	4.4
RADIO INFLUENCE VOLTAGE DATA				
Low-frequency Test Voltage, Kv	22	30	44	4.5
Maximum R.I.V., Microvolts at 1000 Kc	100	200	200	4.5

PROPOSED TDJ-59
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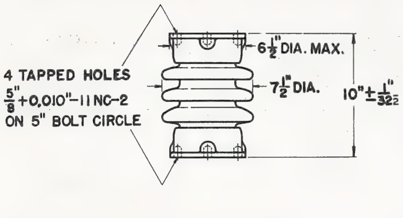
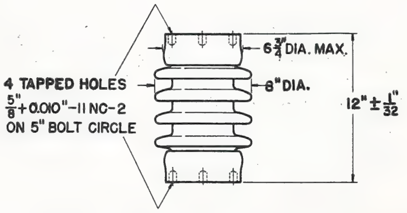
PROPOSED EEI-NEMA STANDARDS

FOR WET PROCESS
PORCELAIN
INSULATORS

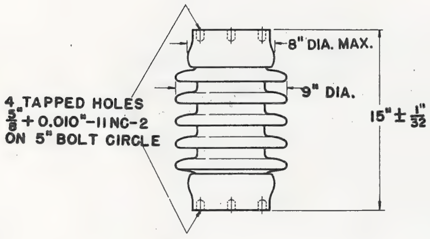
APPARATUS POST TYPE (CONT.)


4 TAPPED HOLES
5/8"+0.010"-11 NC-2
ON 5" BOLT CIRCLE
6 1/2" DIA. MAX.
7 1/2" DIA.
10" ± 1/32"

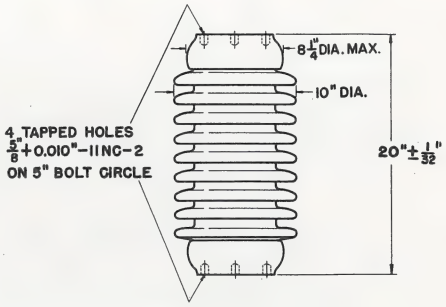
T. R. No. 222


4 TAPPED HOLES
5/8"+0.010"-11 NC-2
ON 5" BOLT CIRCLE
6 3/4" DIA. MAX.
8" DIA.
12" ± 1/32"

T. R. No. 225


4 TAPPED HOLES
5/8"+0.010"-11 NC-2
ON 5" BOLT CIRCLE
8" DIA. MAX.
9" DIA.
15" ± 1/32"

T. R. No. 227


4 TAPPED HOLES
5/8"+0.010"-11 NC-2
ON 5" BOLT CIRCLE
8 1/4" DIA. MAX.
10" DIA.
20" ± 1/32"

T. R. No. 231

Characteristics	Rating				Paragraph In Pub. No. C29.1-1944
TECHNICAL REFERENCE NUMBER	222	225	227	231	
DIMENSIONS					
Leakage Distance, Inches	10½	15½	24	37	2.6.1
Dry Arcing Distance, Inches	6	7¼	10½	14½	2.6.2
MECHANICAL VALUES					
Cantilever Strength, Pounds	4000	4000	4000	4000	5.1.4.1
Tensile Strength, Pounds	10000	10000	10000	14000	5.1.4.3
Torsional Strength, Inch-Pounds	12000	14000	16000	20000	5.1.4.2
Compression Strength, Pounds	20000	20000	20000	30000	5.1.4.4
Tension Proof Test Load, Pounds	2000	2000	2000	2000	7.2.2
ELECTRICAL VALUES					
Low-frequency Flashover—Dry, Kv	60	85	110	145	4.1
Low-frequency Flashover—Wet, Kv	40	55	75	100	4.2
Impulse Flashover—Positive, Kv	105	125	170	225	4.3
Impulse Flashover—Negative, Kv	120	200	250	290	4.3
Low-frequency Withstand—Dry, Kv	35	50	70	95	4.2.9
Low-frequency Withstand—Wet, Kv	30	45	60	80	4.2.10
Impulse Withstand, Kv	95	110	150	200	4.4
RADIO INFLUENCE VOLTAGE DATA					
Low-frequency Test Voltage, Kv	5	10	15	22	4.5
Maximum R.I.V., Microvolts at 1000 Kc	50	50	100	100	4.5

ENTRANCE BUSHINGS

Entrance bushings are mainly used to carry conductors through roofs or walls of buildings or through conducting barriers within buildings. They may take a great variety of forms, several of which are illustrated schematically below. They may consist merely of tubes grouted into the wall with a bus bar or conductor passing through them, or they may have a conductor assembly as an integral part of the bushing.

For higher voltages, entrance bushings are designed with internal insulation like apparatus bushings, except that both ends operate in air and must make use of its dielectric strength. In some cases, such as roof applications, where one side of the bushing is exposed to rain while the other side remains dry, it may be possible to make the inside end somewhat smaller than the outer one.

Since most very high voltage apparatus is of the outdoor type, it is usually not necessary to bring extremely high voltage leads into a building. That is why most entrance bushings are employed on circuits up to 23 or 34.5 KV. For higher voltage application, a 69 KV entrance bushing is catalogued here.
Inquiries for entrance bushings should include the following information:

a. Electrical characteristics required.

b. Mounting Details.

c. Wall or roof thickness.

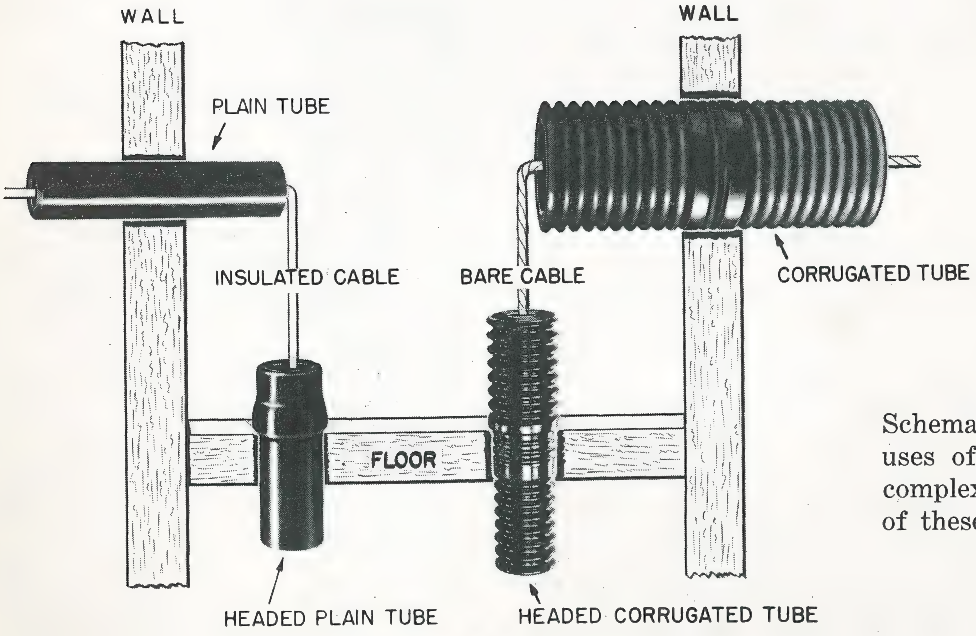
d. Terminal arrangement.

e. Current rating.

f. Kind and size of conductor to be connected to or carried through the bushing.

g. A realistic sketch is often helpful.

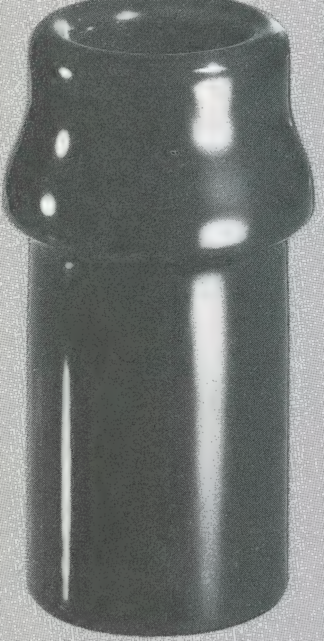
Brown Compression Glaze is Standard for all Entrance Bushings.

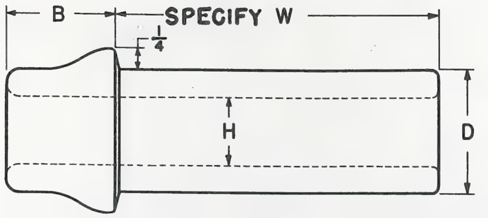


Schematic illustration of primary uses of entrance bushings. More complex forms are often variations of these basic applications.

ENTRANCE
INDOOR

ROUND TUBES
HEADED

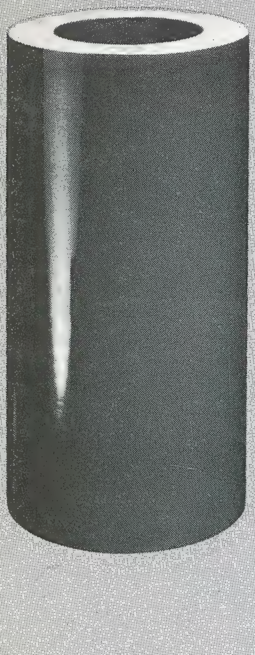


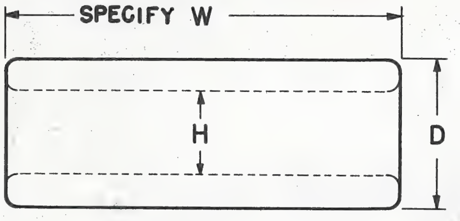


These low voltage tubes, both headed and plain, are generally used with insulated cable, going through masonry or concrete walls. Headed tubes are furnished with W dimensions in multiples of 2 inches. Please specify this dimension on your order.

Catalog Number	Dimensions in Inches		
	B	H	D
7148	1	1	2
7149	1	1¼	2¼
7150	1	1½	2½
7151	1	1¾	2¾
7152	1	2	3
7153	1	2½	3½
7154	1	3	4
7155	2	1	2
7156	2	1¼	2¼
7157	2	1½	2½
7158	2	1¾	2¾
7159	2	2	3
7160	2	2½	3½
7161	2	3	4
7162	3	1	2
7163	3	1¼	2¼
7164	3	1½	2½
7165	3	1¾	2¾
7166	3	2	3
7167	3	2½	3½
7168	3	3	4

ROUND TUBES
PLAIN





Plain tubes are furnished with any specified W dimension. Plain tubes, up to 18 ft. long have been successfully made by Locke.

Catalog Number	Dimensions in Inches	
	H	D
9320	1	2
9321	1¼	2¼
9322	1½	2½
9323	1¾	2¾
9324	2	3
9325	2	3½
9326	2½	3½
9327	2½	4
9328	3	4
9329	3	4½
9330	3	5
9331	3½	4½
9332	3½	5
9333	3½	5½
9334	4	5½
9335	4	6
9336	4	6½
9337	5	7

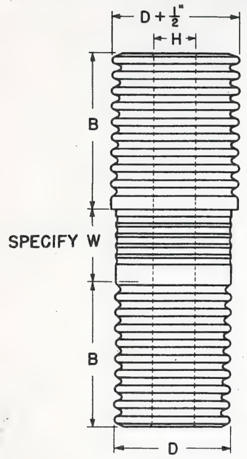
Recommended minimum extensions of plain and headed tubes from each side of floor or wall. For insulated conductors.

Voltage KV	Extension Inches
2.3	1
4.4	2
6.6	3

BUSHINGS
TYPE

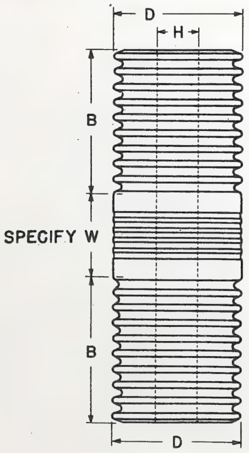
Used largely in indoor bus structures of central stations, the headed bushings are designed for use in floors, plain ones for use in walls. They are furnished with W dimensions in multiples of 2 inches. Please specify this dimension on your order. For recommended minimum extensions, note tables on opposite page and on page 159.

ROUND FLOOR BUSHINGS
CORRUGATED-HEADED



TYPE A

ROUND WALL BUSHINGS
CORRUGATED

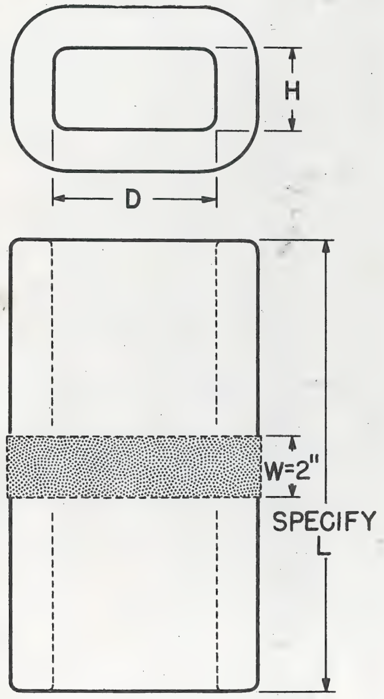


TYPE B

A				B
Catalog Number	Dimensions—Inches			Catalog Number
	B	H	D	
28300	3	1	2½	28400
28301	4	1	2½	28401
28302	5	1	2½	28402
28303	6	1	2¾	28403
28304	8	1	2¾	28404
28305	10	1	3	28405
28306	12	1	3½	28406
28307	3	1½	3	28407
28308	4	1½	3	28408
28309	5	1½	3	28409
28310	6	1½	3¼	28410
28311	8	1½	3¼	28411
28312	10	1½	3½	28412
28313	12	1½	4	28413
28314	3	2	3½	28414
28315	4	2	3½	28415
28316	5	2	3½	28416
28317	6	2	3¾	28417
28318	8	2	3¾	28418
28319	10	2	4	28419
28320	12	2	4½	28420
28321	3	2½	4	28421
28322	4	2½	4	28422
28323	5	2½	4	28423
28324	6	2½	4¼	28424
28325	8	2½	4¼	28425
28326	10	2½	4½	28426
28327	12	2½	5	28427
28328	3	3	4½	28428
28329	4	3	4½	28429
28330	5	3	4½	28430
28331	6	3	4¾	28431
28332	8	3	4¾	28432
28333	10	3	5	28433
28334	12	3	5½	28434
28335	3	3½	5	28435
28336	4	3½	5	28436
28337	5	3½	5	28437
28338	6	3½	5¼	28438
28339	8	3½	5¼	28439
28340	10	3½	5½	28440
28341	12	3½	6	28441
28342	3	4	5¾	28442
28343	4	4	5¾	28443
28344	5	4	5¾	28444
28345	6	4	6	28445
28346	8	4	6	28446
28347	10	4	6¼	28447
28348	12	4	6½	28448
28349	3	4½	6¼	28449
28350	4	4½	6¼	28450
28351	5	4½	6¼	28451
28352	6	4½	6½	28452
28353	8	4½	6½	28453
28354	10	4½	6¾	28454
28355	12	4½	7	28455

ENTRANCE
INDOOR

RECTANGULAR BUSHINGS
PLAIN



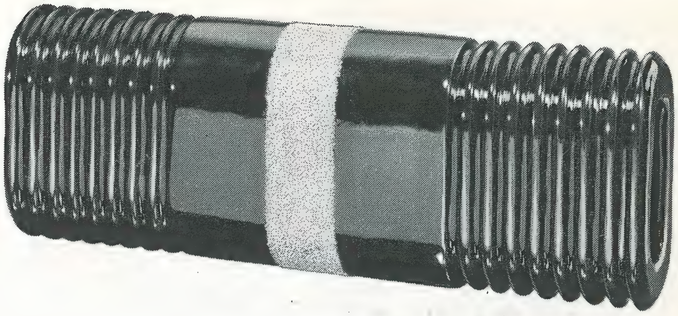
For use with bus bars or stacks. In selecting these bushings, choose hole size at least ½″ larger than the bus bar or stack to be accommodated. This allows for variation in expansion and dimensions. As the W dimension on all plain bushings is 2″, only L should be specified on orders. If possible, also indicate the size of the conductor to be used.

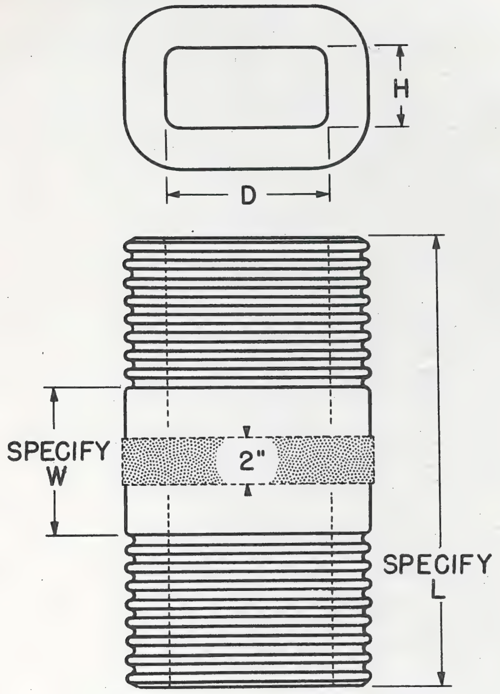
Tubes of high mechanical and electrical strength can be supplied to practically any required dimensions, limited only by the size of firing kilns.

Catalog Number	Dimensions in Inches		
	Outside Dimensions	Hole Size	
		H	D
28101	3¼ x 4½	1¼	2½
28103	3¼ x 5	1¼	3
28105	3¼ x 5½	1¼	3½
28107	3¼ x 6	1¼	4
28109	3¼ x 6½	1¼	4½
28111	3¾ x 7½	1¼	5
28113	3¾ x 8	1¼	5½
28115	3¾ x 8½	1¼	6
28117	3¾ x 4½	1¾	2½
28119	3¾ x 5	1¾	3
28121	3¾ x 5½	1¾	3½
28123	3¾ x 6	1¾	4
28125	3¾ x 6½	1¾	4½
28127	4¼ x 7½	1¾	5
28129	4¼ x 8	1¾	5½
28131	4¼ x 8½	1¾	6
28133	4¼ x 4½	2¼	2½
28135	4¼ x 5	2¼	3
28137	4¼ x 5½	2¼	3½
28139	4¼ x 6	2¼	4
28141	4¼ x 6½	2¼	4½
28143	4¾ x 7½	2¼	5
28145	4¾ x 8	2¼	5½
28147	4¾ x 8½	2¼	6
28149	4¾ x 5	2¾	3
28151	4¾ x 5½	2¾	3½
28153	4¾ x 6	2¾	4
28155	4¾ x 6½	2¾	4½
28157	5¼ x 7½	2¾	5
28159	5¼ x 8	2¾	5½
28161	5¼ x 8½	2¾	6
28163	5¼ x 5½	3¼	3½
28165	5¼ x 6	3¼	4
28167	5¼ x 6½	3¼	4½
28169	5¾ x 7½	3¼	5
28171	5¾ x 8	3¼	5½
28173	5¾ x 8½	3¼	6
28175	5¾ x 6	3¾	4
28177	5¾ x 6½	3¾	4½
28179	6¼ x 7½	3¾	5
28181	6¼ x 8	3¾	5½
28183	6¼ x 8½	3¾	6
28185	6¼ x 6½	4¼	4½
28187	6¾ x 7½	4¼	5
28189	6¾ x 8	4¼	5½
28191	6¾ x 8½	4¼	6
28193	7¼ x 7½	4¾	5
28195	7¼ x 8	4¾	5½
28197	7¼ x 8½	4¾	6
28199	7¾ x 8	5¼	5½
28201	7¾ x 8½	5¼	6
28203	8¼ x 8½	5¾	6

BUSHINGS
TYPE

RECTANGULAR BUSHINGS
CORRUGATED



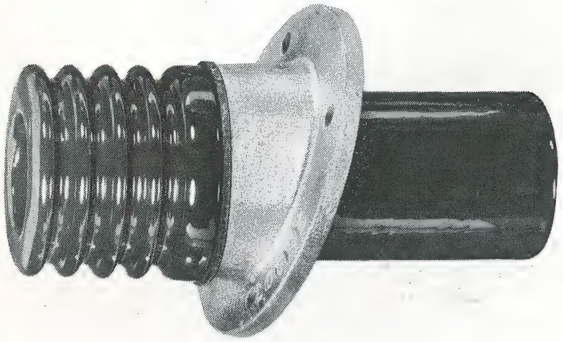


For use above 15 KV, corrugated bushings are recommended. They are furnished with W dimensions in multiples of 2 inches. Please specify this dimension on your order.

Recommended minimum extensions of rectangular and round bushings from each side of floor or wall.
For bare conductors.

Voltage KV	Extension—Inches	
	Plain	Corrugated
5	4	3
7.5	5	4
15	7	6
23	Not Recomm.	8

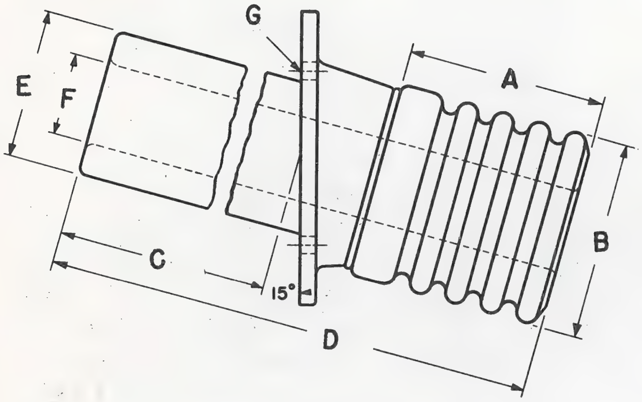
Catalog Number	Dimensions in Inches		
	Outside Dimensions	Hole Size	
		H	D
28900	3¾ x 5	1¼	2½
28901	3¾ x 5½	1¼	3
28902	3¾ x 6	1¼	3½
28903	3¾ x 6½	1¼	4
28904	3¾ x 7	1¼	4½
28905	3¾ x 7½	1¼	5
28906	3¾ x 8	1¼	5½
28907	3¾ x 8½	1¼	6
28908	4¼ x 5	1¾	2½
28909	4¼ x 5½	1¾	3
28910	4¼ x 6	1¾	3½
28911	4¼ x 6½	1¾	4
28912	4¼ x 7	1¾	4½
28913	4¼ x 7½	1¾	5
28914	4¼ x 8	1¾	5½
28915	4¼ x 8½	1¾	6
28916	4¾ x 5	2¼	2½
28917	4¾ x 5½	2¼	3
28918	4¾ x 6	2¼	3½
28919	4¾ x 6½	2¼	4
28920	4¾ x 7	2¼	4½
28921	4¾ x 7½	2¼	5
28922	4¾ x 8	2¼	5½
28923	4¾ x 8½	2¼	6
28924	5¼ x 5½	2¾	3
28925	5¼ x 6	2¾	3½
28926	5¼ x 6½	2¾	4
28927	5¼ x 7	2¾	4½
28928	5¼ x 7½	2¾	5
28929	5¼ x 8	2¾	5½
28930	5¼ x 8½	2¾	6
28931	5¾ x 6	3¼	3½
28932	5¾ x 6½	3¼	4
28933	5¾ x 7	3¼	4½
28934	5¾ x 7½	3¼	5
28935	5¾ x 8	3¼	5½
28936	5¾ x 8½	3¼	6
28937	6¼ x 6½	3¾	4
28938	6¼ x 7	3¾	4½
28939	6¼ x 7½	3¾	5
28940	6¼ x 8	3¾	5½
28941	6¼ x 8½	3¾	6
28942	6¾ x 7	4¼	4½
28943	6¾ x 7½	4¼	5
28944	6¾ x 8	4¼	5½
28945	6¾ x 8½	4¼	6
28946	7¼ x 7½	4¾	5
28947	7¼ x 8	4¾	5½
28948	7¼ x 8½	4¾	6
28949	7¾ x 8	5¼	5½
28950	7¾ x 8½	5¼	6
28951	8¼ x 8½	5¾	6



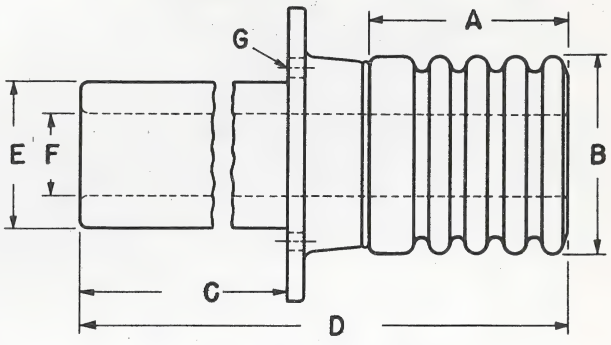
ENTRANCE
OUTDOOR

These low voltage outlet bushings are widely used in meter house connections to insulate primary circuit outlets and for similar applications. The standard flanges are cast from high grade grey iron, double hot-dip galvanized. When currents of 600 amperes and above are stipulated, bronze flanges are furnished. Bushings with one or both ends of special length can be furnished on request.

OUTLET BUSHINGS
LOW VOLTAGE

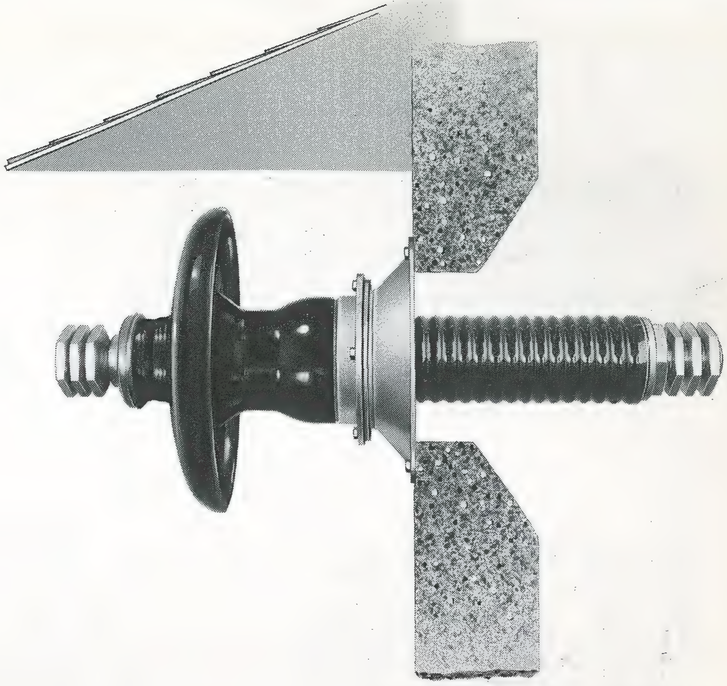


ANGLE MOUNTING
NOS. 8370, 24050, 24156



STRAIGHT MOUNTING
NOS. 24344, 24345, 24346

Catalog Number	Dimensions—Inches						Holes—G		Approx. Lbs. Each		Std. Pkg. Quan.
	A	B	C	D	E	F	Number	Size Inches	Net	Pkd.	
ANGLE MOUNTING **8370**	2	2½	3⅛	6	1¾	¾	4	¼, 3³⁄₁₆BC	2⅛	2⅞	18
24050	3	3	3¹⁵⁄₁₆	8⅛	2¼	1¼	4	⁵⁄₁₆, 3¾BC	3¾	5	12
24156	3	3½	4⁵⁄₃₂	8½	2¾	1¾	4	⁷⁄₁₆, 4½BC	5	6⅛	10
STRAIGHT MOUNTING **24344**	2	2½	3¹⁄₁₆	6	1¾	¾	4	¼, 3³⁄₁₆BC	2⅛	2⅞	18
24345	3	3	3¹³⁄₁₆	8⅛	2¼	1¼	4	⁵⁄₁₆, 3¾BC	3¾	5	12
24346	3	3½	4³⁄₁₆	8½	2¾	1¾	4	⁷⁄₁₆, 4½BC	5	6⅛	10



While these insulators may be fully exposed to the weather, a simple roof will protect them from falling ice and direct snow. Note conical hole for increased electrical clearance at indoor end.

ROOF AND WALL BUSHINGS
FOR THICK WALLS

Locke series 18500 entrance bushings are intended for carrying leads through roof and wall barriers of brick and concrete. They are designed for maximum wet flashover values on the outdoor end and high dry flashover on the end projecting into the building.

These roof and wall entrance bushings have long effective leakage distance. They are mechanically strong, easy to install and have been proven by many years of satisfactory service.

The insulating element is a single porcelain tube. For currents below 600 amperes, a small, heavily galvanized, malleable-iron mounting ring is cemented to the porcelain. When the conductor through the bushing is to carry 600 amperes or more, high strength bronze mounting rings are furnished.

The mounting base is attached to the wall or roof with expansion bolts. To make full electrical use of the indoor shank end of the bushing, it is usually desirable—particularly with thick walls—to make the hole through the wall as large as possible. It may be made conical, for increased electrical clearance, as illustrated above. Holes cut just large enough to permit passage of the porcelain, cut down the clearance between the inside terminal and ground, materially reducing the bushing's electrical characteristics.

A complete line of copper rod assemblies for use in these bushings is shown on page 163. These assemblies are completely mechanical and require no further cementing. When necessary, the conductor may be changed after the bushing is installed, without removing the bushing from its mounting.

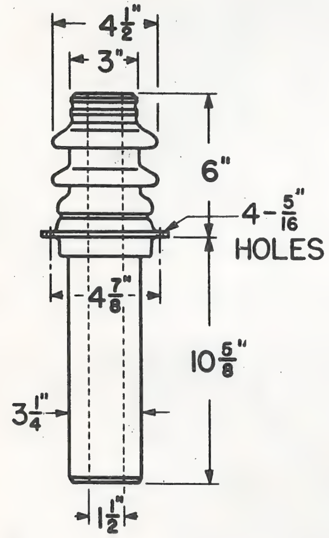
For higher operating voltages, where the situation warrants it, oil filled bushings suitable to the application can be furnished on your request. See page 165.

ENTRANCE
OUTDOOR

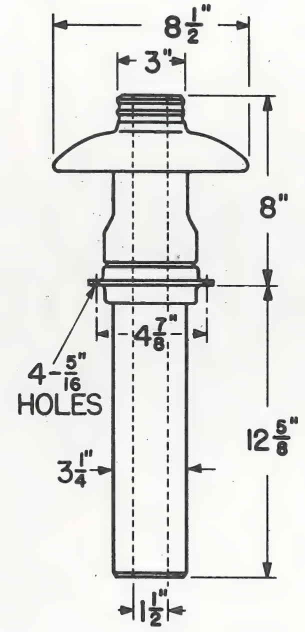
ROOF AND WALL BUSHINGS
FOR THICK WALLS
6.6 TO 22 KV.

Select rod assemblies for these bushings from opposite page. Bushings, sub-bases and rod assemblies are packed separately.

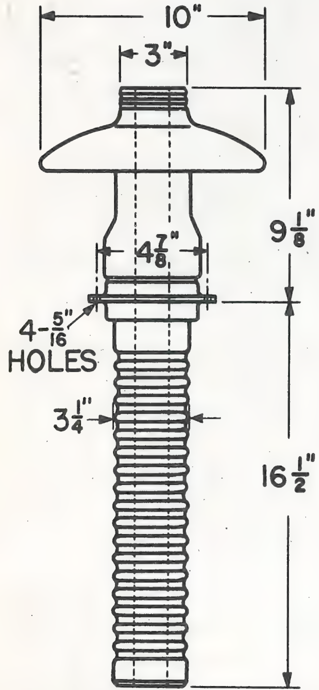
Catalog Number	Voltage Rating KV	Lbs. Net
18501	6.6	12
18502	11	15
18503	22	30


4 1/2"
3"
6"
4-5/16" HOLES
4 7/8"
10 5/8"
3 1/4"
1 1/2"

NO. 18501


8 1/2"
3"
8"
4 7/8"
4-5/16" HOLES
12 5/8"
3 1/4"
1 1/2"

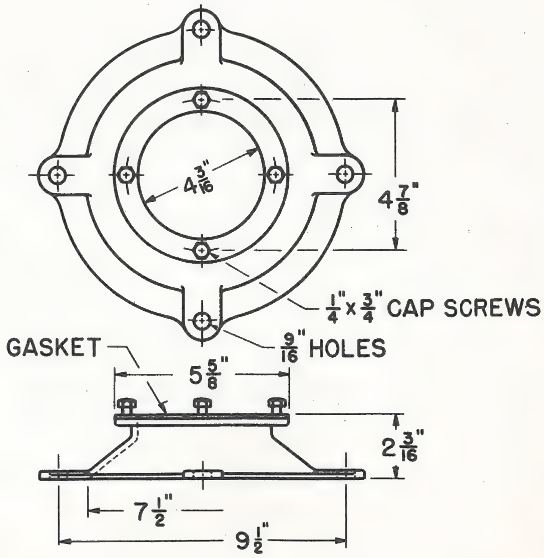
NO. 18502


10"
3"
9 1/8"
4 7/8"
4-5/16" HOLES
3 1/4"
16 1/2"
1 1/2"

NO. 18503

SUB-BASE
NO. 13328

This sub-base is for use with the bushings on this page. Weight: 5 lbs. For currents below 600 amperes, it is made of hot-dip galvanized malleable iron. For currents above 600 amperes, it is high strength bronze.

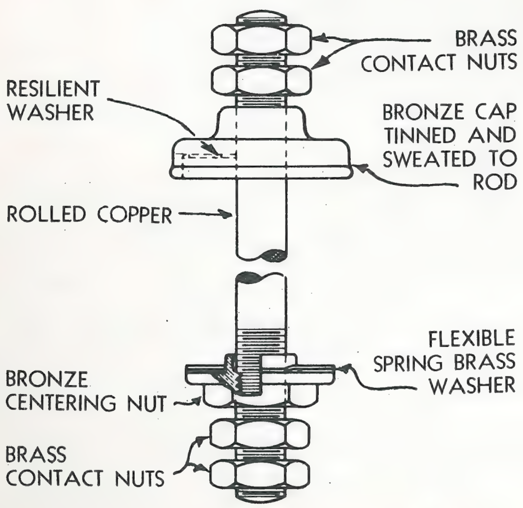

4 3/16"
4 7/8"
1/4" x 3/4" CAP SCREWS
9/16" HOLES
GASKET
5 5/8"
2 3/16"
7 1/2"
9 1/2"

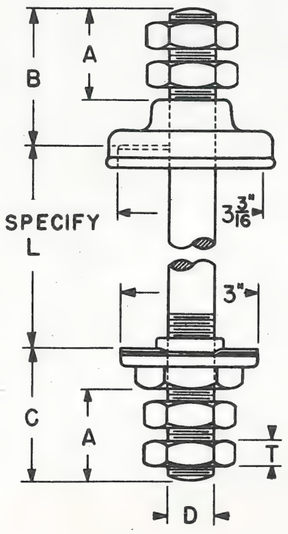
BUSHINGS
TYPE

ROD ASSEMBLIES
FOR THICK WALL, ROOF AND WALL BUSHINGS
6.6 TO 22 KV.

Catalog Number	Dimensions—Inches						Approx. Lbs. Ea. Pkd.	Use with Bushing No.
	A	B	C	D	T	L		
19600	2	3	2 7/8	5/8	1/2	17 1/8	5 1/4	18501
19601						21 1/8	5 3/4	18502
19602						26 1/8	6 1/4	18503
19608	2	3	2 7/8	3/4	1/2	17 1/8	6 1/4	18501
19609						21 1/8	6 3/4	18502
19610						26 1/8	7 1/4	18503
19616	2 1/2	3 1/2	3 3/8	1	3/4	17 1/8	8 3/4	18501
19617						21 1/8	9 3/4	18502
19618						26 1/8	11 1/2	18503
19624	3 1/4	4 1/4	4 1/8	1 1/4	1	17 1/8	13 1/4	18501
19625						21 1/8	15 1/4	18502
19626						26 1/8	17 1/4	18503

Recomm. Current Rating Amps.	Rod Diam. Inches	Threads per Inch
300	5/8	11
400	3/4	12
800	1	12
1200	1 1/4	12


BRASS CONTACT NUTS
RESILIENT WASHER
BRONZE CAP TINNED AND SWEATED TO ROD
ROLLED COPPER
FLEXIBLE SPRING BRASS WASHER
BRONZE CENTERING NUT
BRASS CONTACT NUTS

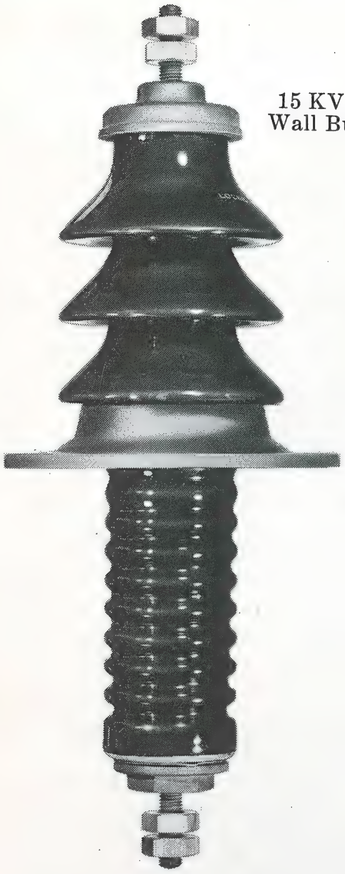

A
B
SPECIFY L
3 3/16"
3"
C
A
T
D

Locke threaded rod assemblies are designed for use with standard bushings and many special applications.

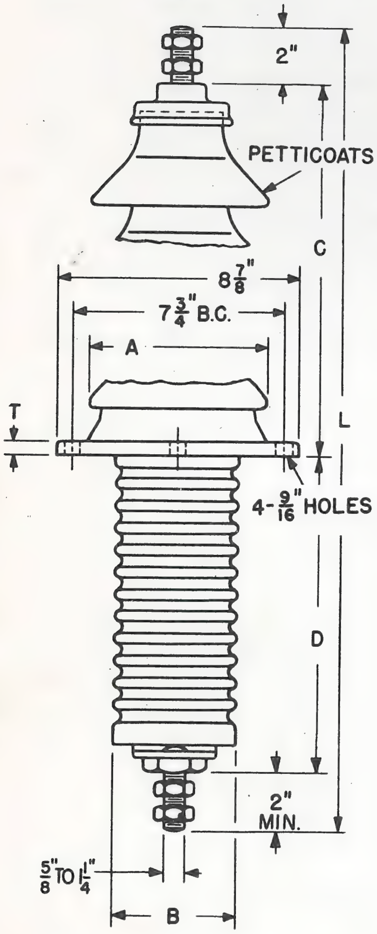
A hex-centering nut, backed up with a flexible spring brass washer, centers the conductor and maintains proper spring tension to keep the centering nut snugly against the porcelain at all times.

These rod assemblies can be furnished with any desired L dimension. Please specify on order. Rods of other diameters available on request.

ENTRANCE
OUTDOOR



15 KV Thin Wall Bushing



NOS. 24217-24220

ROOF AND WALL BUSHINGS
FOR THIN WALLS
7.5 TO 34.5 KV.

A shorter shank differentiates these bushings from the thick wall types. Their extreme reliability has made them favorites of switch house engineers for the thin walls of metal switch houses or panels. They fully meet NEMA standard flashover requirements and are designed so that the surrounding air is used with maximum efficiency.

Deep, sloping hoods on the outside ends give high resistance to current leakage. They are sufficiently steep to shed snow, sleet or rain readily. The shanks, with deep corrugations starting at the flange line, have high flashover value for their length.

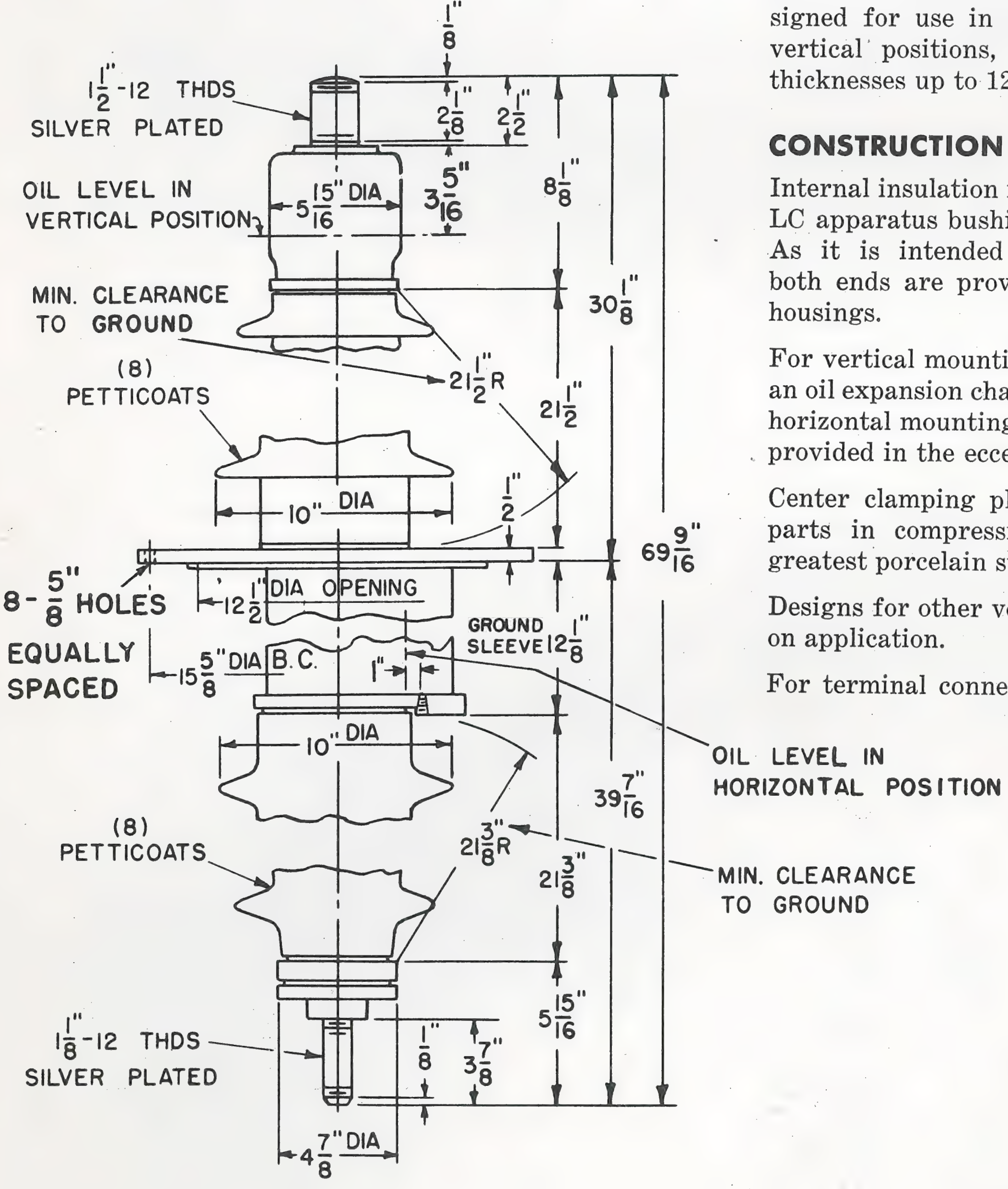
A 5/8″ diameter copper rod conductor is held firmly in place. It is equipped with two contact nuts at each end, as shown. Other sizes up to 1¼″ can be furnished or can be substituted after installation, without removing the bushing from its mounting. Please specify rod size and desired ampere rating on your order. The flanges of these bushings, regardless of rating, have identical overall and bolt circle diameters. Bushings can be exchanged without the expense and labor of relocating mounting holes. Flanges for current ratings below 600 amperes are painted grey iron. Above this rating, they are cast bronze.

Recommended Current Rating Amperes	Rod Diameter Inches	Threads per Inch
300	⅝	11
400	¾	12
800	1	12
1200	1¼	12

Catalog Number	Rating KV	Flashover KV NEMA Std.		No. of Petticoats	Dimensions—Inches						Approx. Lbs.		Std. Pkg. Quan.
		Dry Indoor End	Wet Outdoor End		A	B	C	D	L	T	Net	Pkd.	
24217	7.5	50	35	2	6	3½	8	7¼	19¾	⅜	22	32	2
24218	15	70	50	3	6	3½	10	8½	23¹⁄₁₆	⅜	26	36	2
24219	23	90	70	4	6½	4½	13⅛	11⅛	28¹⁵⁄₁₆	½	43	58	2
24220	34.5	120	95	5	6½	4½	17	18⅞	40¹⁵⁄₁₆	½	58	78	2

BUSHINGS
TYPE

ROOF AND WALL BUSHINGS
OIL FILLED
69 KV. 600 AMP.



1/8"
1 1/2"-12 THDS SILVER PLATED
2 1/8"
2 1/2"
OIL LEVEL IN VERTICAL POSITION
5 15/16" DIA
3 5/16"
8 1/8"
MIN. CLEARANCE TO GROUND
30 1/8"
(8) PETTICOATS
21 1/2" R
21 1/2"
10" DIA
1/2"
69 9/16"
8-5/8" HOLES EQUALLY SPACED
12 1/2" DIA OPENING
GROUND SLEEVE 12 1/8"
15 5/8" DIA B.C.
1"
OIL LEVEL IN HORIZONTAL POSITION
10" DIA
39 7/16"
(8) PETTICOATS
21 3/8" R
21 3/8"
MIN. CLEARANCE TO GROUND
5 15/16"
1 1/8"-12 THDS SILVER PLATED
1/8"
3 7/8"
4 7/8" DIA

NO. 85808

This bushing takes advantage of the radio-noise free characteristics of modern oil-filled bushing designs. Its voltage withstand level is comparable to 69 KV apparatus bushing standards. It is designed for use in either horizontal or vertical positions, with wall or roof thicknesses up to 12 inches.

CONSTRUCTION FEATURES

Internal insulation is typical of the type LC apparatus bushing. (See page 175) As it is intended for air-to-air use, both ends are provided with porcelain housings.

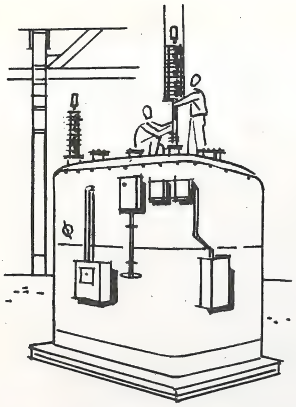
For vertical mounting, this bushing has an oil expansion chamber at the top. For horizontal mounting, expansion space is provided in the eccentric ground sleeve.

Center clamping places both porcelain parts in compression which develops greatest porcelain strength.

Designs for other voltages are available on application.

For terminal connectors, see page 191.

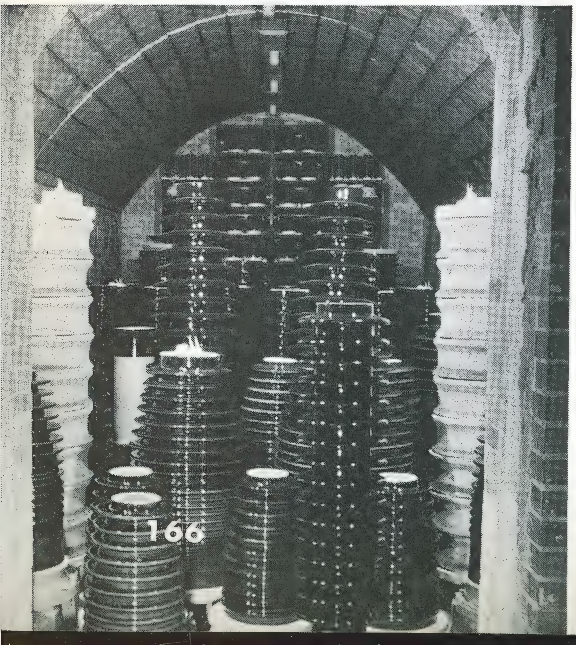
APPARATUS GENERAL



LOCKE APPARATUS BUSHINGS

Locke apparatus bushings—dry-type and oil-filled—cover the entire range of apparatus applications. With many leading apparatus manufacturers, Locke bushings are standard. They have found for many years that Locke bushings are easily adaptable to the requirements of their equipment and give continuous, noise-free service at normal operating voltages, while withstanding a wide range of over-voltages.

Design and manufacture of the bushings shown here are based on long, successful experience. For illustrations of manufacture and assembly, see pages 26-31. Precision made porcelain shells . . . center-clamping for superior strength . . . Nitrile synthetic rubber seals . . . high permanent dielectric strength and low power factor . . . freedom from corona . . . make Locke Apparatus Bushings dependable parts of power transformers and circuit breakers.



Very large or special bushing porcelain is fired in periodic kilns such as the one shown here just before unloading.

MATERIALS

PORCELAIN

The porcelain shells of Locke apparatus bushings represent a combination of competent design with skilled manufacture. Their designs take advantage of all the inherent insulating strength and durability of fine Locke electrical porcelain. Continuous ceramic control and research assure finest manufacturing quality and exact proportions. See illustrations on pages 26 to 29.

Locke Compression Glaze and center clamping bushing design put the porcelain under compression to develop its full potential strength. The bottom porcelains of circuit breaker bushings are covered with a special glaze, developed by Locke, to inhibit carbon deposition and maintain high creepage.

METALS

Center tubes of draw lead bushings are aluminum or copper. Current carrying center conductors are copper rods or tubes, of a diameter consistent with the bushing's current rating. Terminal assemblies are precision machined and external terminal studs 800 amperes and above are silver plated for fullest electrical contact. Flanges are cast iron or steel but on bushings requiring non-magnetic properties, they are high strength bronze or aluminum.

ORGANIC INSULATION

PAPER

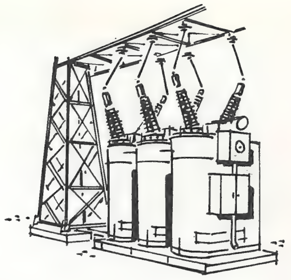
Type U high voltage apparatus bushings contain internal insulation of high quality Kraft paper which is impregnated by the bushing oil. Combined with precisely placed strips of Rescon* conducting paint equalizers within the paper roll for proper grading of voltage stresses, this form of organic insulation has proven highly effective and durable.

HERKOLITE* INSULATION

Portions of type LC and superseded type F bushings consist of Herkolite* insulation.

*Reg. T. M. General Electric Company

BUSHINGS INFORMATION



This material is made of carefully inspected Kraft paper, rolled and laminated with resin into a solid body of high dielectric strength and resistance to oil penetration. In accordance with specific designs, layers of conducting Rescon paint are incorporated into Herkolite bodies. Specially devised control techniques assure the uniformity and solidity of Herkolite Insulation.

OIL

Liquid filled bushings of late designs are filled with degasified 10C oil, topped off by Nitrogen under slight, positive pressure.

GASKETS

All gaskets on Locke apparatus bushings are made of Nitrile synthetic rubber which, experience has shown, is an ideal material for the sealing of oil-filled spaces.

INTERCHANGEABILITY

Standard Locke apparatus bushings are designed to be interchangeable with similar bushings now in service. Their flange dimensions cover a large proportion of recognized bushing types. Where bushings of unusual dimensions are to be replaced, adapters are available. All Locke apparatus bushings are interchangeable with General Electric bushings of the same types. Before substitution is made, it should be assured that the dimensions of the replacement bushing fit the particular apparatus model.

BUSHING IDENTIFICATION FROM CATALOG NUMBER

Type and Class letters, such as "Type U, Class BJ138H" are used for easy reference to Locke Bushings.

TYPE

The Type indicates the general bushing construction, such as:

Type A—Dry type, 8.7 to 25 KV
Type LC—Oil filled, 23 to 69 KV
Type U—Oil filled, above 69 KV

CLASS

The bushing class designates application, voltage and altitude ratings. The symbols should be interpreted as follows:

FIRST LETTER

A—Power or distribution transformer bushing
B—Oil circuit breaker bushing
C—Current or metering transformer bushing

SECOND AND THIRD LETTER

D—Auxiliary support flange omitted
J—Bushing with capacitance tap
P— For use in askarel (Pyranol* or similar liquid).
U—For use in oil or askarel filled apparatus
Y—Special design modifications, such as special length ground sleeve

NUMBER

The number gives the normal rated circuit voltage in kilovolts.

LAST LETTER

This indicates the altitude for use of the bushing at rated voltage.
No letter—0 to 3300 ft. above sea level
A—0 to about 10,000 ft. above sea level-oversize bushing
H—3301 to about 10,000 ft.—high altitude bushing

EXAMPLES

Class A25A is for transformer use, rated 25 KV, for use anywhere up to 8,100 ft. above sea level. A Class BJ138H bushing is for circuit breaker use, with capacitance tap, rated 138 KV. It is a high altitude bushing for use between 3301 and 9400 ft.

APPLICATION DATA

STANDARD ELECTRICAL CHARACTERISTICS

Test voltages shown below are in accordance with AIEE Standard No. 21, ASA Standard C 76.1 (page 196), as modified by ASA Standard C 37.4a-1954. (Superseded bushings in 83000 series (page 185, 187) do not conform, as they were designed prior to these standards).

Bushing Voltage Rating Kv	Standard Creepage Inches—Min	60-Cycle Withstand Test		BIL; Full Wave Impulse Dry Withstand 1.5 x 40 Micsec—Kv
		1-min Dry Kv—RMS	10-sec Wet Kv—RMS	
8.66	7*	35	30	95
15	11	50	45	110
25	17	70	70	150
34.5	26.5	95	95	200
46	35	120	120	250
69	48.5	175	175	350
92**	53	225	190	450
115	66	280	230	550
138	79	335	275	650
161	92	385	315	750
180*	114*	425*	350*	825*
196	114	465	385	900
230	135	545	445	1050
260*	170*	615*	500*	1175*
287.5	170	680	555	1300
345*	205*	810*	665*	1550*

*Does not appear in ASA standards.

**Listed in ASA standards for transformer use only.

Bushings are generally recommended for apparatus rated up to the nominal bushing rating. They may be used on apparatus of higher voltage rating when adequate for the particular application.

CURRENT RATINGS

Listed ampere ratings are the maximum continuous current carrying capacity of the bushing. Overloads of short duration are usually permissible under the overload conditions applying to the apparatus involved.

STANDARD TERMINAL PRACTICE

Top or bottom terminals are not considered integral parts of the bushing. When required, they should be specified separately on the order.

EFFECTIVE GROUND SLEEVE LENGTH

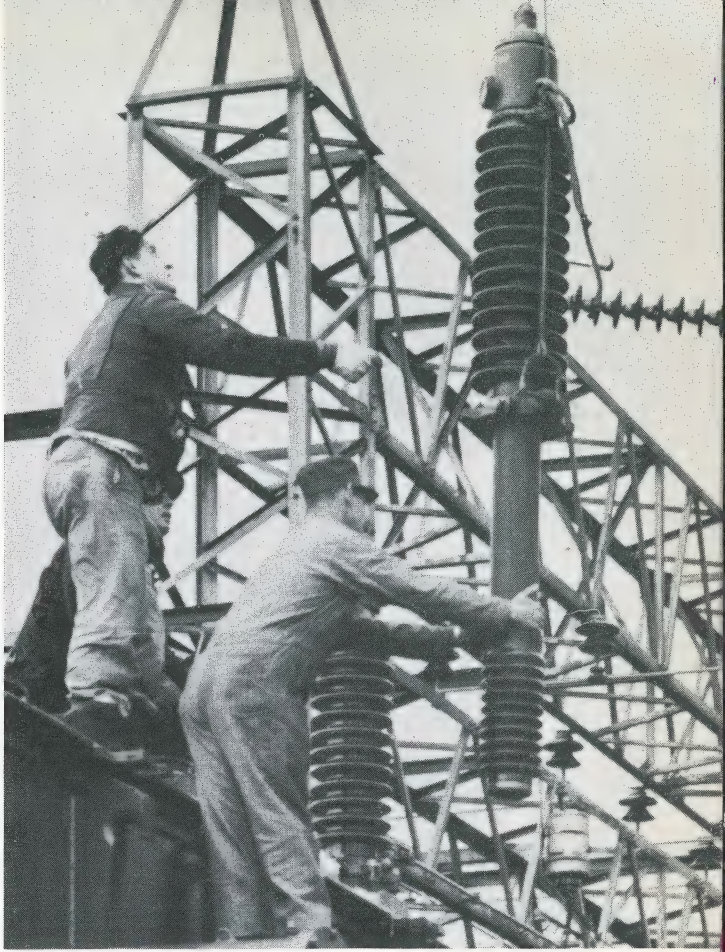
Effective ground sleeve length is the distance from the flange gasket surface to the minimum oil level, one-half inch above the lower end of the ground sleeve.

The insulating liquid in the apparatus must always be above this level. The manufacturer's selection of the effective ground sleeve length will depend on the apparatus design.

POWER FACTOR TESTS

The most significant method of investigating the dielectric condition of installed bushings is the successive measurement of their power factors. The power factor of the bushing dielectric is measured periodically under applied voltage of approximately normal frequency. Increase in power factor over a series of measurements is evidence that an unsatisfactory condition is progressing. The test essentially measures the performance of the organic insulating elements such as oil, paper or Herkolite insulation. The power factor of new standard bushings (except type A) is measured at the factory, recorded by serial number and is available on request. For significant results, however, only a series of field measurements showing increasing power factor should be accepted as a sign of developing trouble. Power factor tests should not be

BUSHINGS INFORMATION



made above operating voltage, as the formation of external corona would result in increased power factor measurement which would not reveal the internal condition of the bushing. When conducting power factor tests, these general rules should be followed: They should be made in clear weather, while the air temperature is above 10°C and the relative humidity below 80%. The temperature of the bushing porcelain should not be below air temperature. The porcelain must be clean and dry.

Bushing power factor tests may be conducted while the bushing is removed from the apparatus for servicing, or in place on the apparatus. In the latter case, test procedures are provided, whether the bushing is electrically isolated or not.

The frequency of power factor tests depends on specific operating conditions and cannot be generally recommended. Power factor testing of standard Locke apparatus bushings: Type U—A capacitance tap is furnished on all type U bushings as standard construction and provides for convenient power factor testing (see page 180).

Type LC—Where provision for power factor test is included in the bushing, this consists of a second mounting flange, gasketed for isolation from the support flange. A special link is "unlatched" for the power factor test.

This bushing also lends itself to special insulated mounting on apparatus covers, with the insulated feature part of the apparatus, rather than the bushing. This allows standard bushings to be used, regardless of power factor test requirements.

Type A—As this bushing is usually made entirely of inorganic material. no power factor testing is required.

For further information on this subject, write for the Locke Apparatus Bushing Bulletin on "Power Factor Tests" which is now in preparation.

HIGH ALTITUDE APPLICATION

At altitudes above 3,300 feet, changed atmospheric conditions demand longer creepage and greater arcing distance. For this purpose, Oversize (letter A at end of class numerals) and High Altitude (letter H) bushings have longer top porcelains.

Class H bushings should not be flashover tested below 3,300 feet unless gapped down, because the flashover voltage at low altitude would be too high for the internal insulation.

BUSHINGS FOR HIGH ALTITUDES

CIRCUIT BIL (KV)	BUSHING CLASS (KV)	*MAXIMUM ALTITUDE (FT)	BUSHING CLASS (KV)	*MAXIMUM ALTITUDE (FT)	BUSHING CLASS (KV)	*MAXIMUM ALTITUDE (FT)
75	8.7	11700	15A	15000	25A	15000
95	8.7	3300	15A	13200	25A	15000
110	15A	8100	25A	15000	34.5	15000
150	25A	8100	34.5	13600	46	15000
200	34.5	8100**	46	11000	69	15000
250	46	8100**	69	15000	92	15000
350	69	8100**	92	12200	115	15000
450	92	3300	115	10500	138	15000
550	115	3300	138	9400	161	14500
650	138	3300	161	8100	180	11800
750	161	3300	180	6800	196	9800
825	180	3300	196	6600	230	12000
900	196	3300	230	9000	287.5	15000
1050	230	3300	287.5	11000	345	15000
1300	287.5	3300	345	9600	....	......
1550	345	3300	....	......	....	......

NOTES:

No. 1—Altitude ratings based on ability of bushing to demonstrate withstand test voltages (60 cycle and impulse) at the high altitude.

No. 2—Altitude ratings based on correction factors varying as relative air density to the 0.75 power for altitudes in excess of 3300 feet.

* Bushings suitable for a given altitude may be used at higher altitudes providing the reduced flashover values are acceptable.

**Limited to 3300 ft. for pre-ASA bushings shown on pages 185 and 187.

UNFAVORABLE ATMOSPHERIC CONDITIONS

Deposits of dirt on bushing surfaces, such as dust, salt, cement, chemical fumes, etc., usually produce little detrimental effect when the bushing is dry or during normal rainfall. However, slight dampness caused by fog, dew or a light drizzle will cause a dirty bushing to lose some of its electrical strength and may, in some cases, result in flashover at a stress not far above operating voltage. The following steps may be taken to avoid this condition:

A. Protective coating of the porcelain surface with silicone base liquid such as Locke Insulcone (page 202).

B. Frequent cleaning.

C. Replacement of existing bushings with others rated at higher voltage or with extra creepage, such as oversize or high altitude bushings.

D. Install hoods, umbrellas or other barriers to prevent settling of dirt on the porcelain.

Cleaning of bushing porcelains can be accomplished with Lockebrite, a cleaning powder developed by Locke for this purpose, which will be found to be effective in the majority of cases (page 202). Lava soap or steel wool may also be used. Roughening of the glaze surface by abrasive cleaners should be avoided as this will make future cleaning more difficult. Liquid cleaners such as carbon tetrachloride or dilute hydrochloric acid solution may be used if proper precautions are observed. For further information on this subject, see page 15 or write for a Locke Apparatus Bulletin on "Bushings in Dirty Atmospheres" which is now in preparation.

BUSHING INSPECTION

Bushing maintenance programs in use today vary from daily visual inspection to no periodic examination at all. Inspection frequency should be determined by such factors as bushing condition, construction, age, severity of operating conditions, importance of service, accessibility and available personnel. Before any testing or cleaning, a bushing should be

BUSHINGS INFORMATION

de-energized and temporarily grounded to remove electrostatic charges.

POINTS OF INSPECTION

Porcelain parts should be inspected for chipping or cracking from mechanical shocks. Cracks which appear to extend into the porcelain body call for careful checking of the bushing oil level to discover leaks. Chipped petticoats will not affect performance unless effective creepage distance is appreciably reduced. Accumulations of dirt should be treated as outlined under 'Unfavorable Atmospheric Conditions' on the opposite page. Oil gages should be checked for cracks or fractures from mechanical injury.

Structural metal parts should be kept painted and checked for fractures. Oil leakage around gaskets should be traced to detect any possible porcelain break. Oil leakage around old composition cork gaskets can be corrected by installation of new gaskets. Leakage past Nitrile synthetic rubber gaskets can usually be corrected by progressive tightening of clamping bolts around the circumference, a fraction of a turn at a time.

The oil level of type U and F bushings is properly adjusted at the factory and is indicated by the magnetic gage near the bushing top. If the gage pointer is in the red zone below the normal white band, attention is required. Type LC and L bushing are filled and sealed at the factory and require no attention except in case of leakage. The level of the liquid in the apparatus should be checked to assure that the inner end of the bushing is properly immersed. Ground sleeves must reach at least one-half inch into the apparatus oil.

NOISE

An audibly noisy bushing should be checked for loose internal connections. It is suggested that this be done separate from apparatus, as noise has often been traced to the apparatus itself.

Older bushings sometimes interfere with nearby radio and TV reception. They should be replaced with modern bushings, built to NEMA radio noise limits, or should be rebuilt with new radio noise-free factory insulation parts.

As a test of bushing service condition, radio noise tests are significant in predicting incipient dielectric failure only if the radio noise level is appreciably above NEMA limits. The radio noise limit on 69 KV bushings is 2500 Microvolt.

For additional information on bushing inspection and maintenance, write for Locke Apparatus Bushing Bulletin No. 1.

BUSHING REPAIRS

TYPE A

Bushings of this type with through-porcelain construction and without Herkolite insulation, core or liquid filler, are usually more economical to replace than to rebuild, unless their current rating is in excess of 2,000 amperes.

TYPE L-LC

These bushings can be rebuilt economically in the field or service shop. This is particularly true in the case of type LC bushings whose porcelain shells can be replaced with relative ease. Where both porcelain and core are damaged, it is usually advisable to replace the entire bushing.

TYPE U

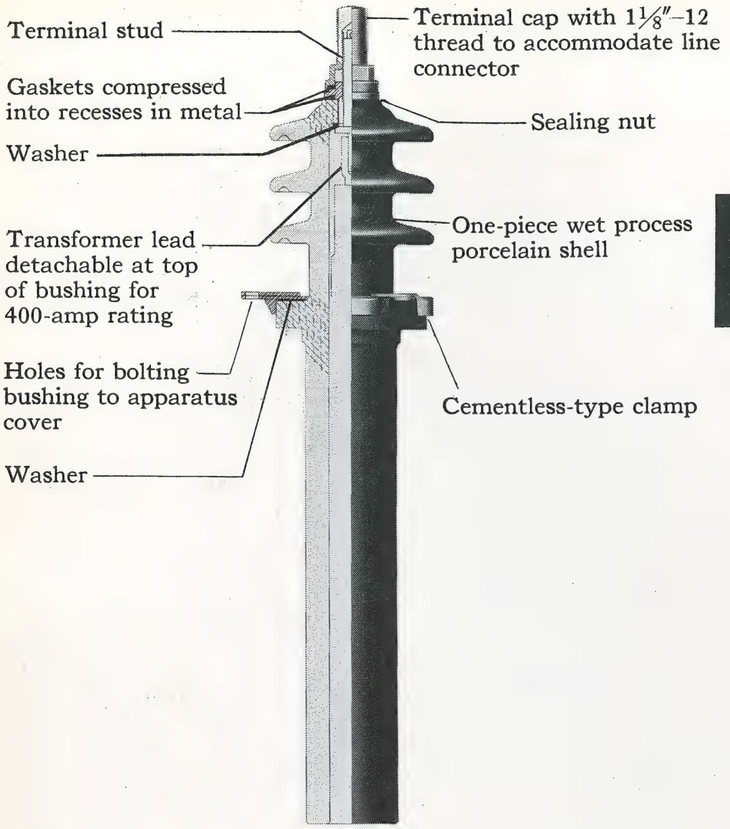
Bushings of this type should be returned to the factory for repairs or rebuilding. In general, these bushings require no servicing beside periodic inspection and cleaning of porcelain surface. For additional information on repair of superseded bushings and bushing age determination, write for Locke Apparatus Bushing Bulletin Number 1.

TYPE F

Bushings of this type, manufactured from 1948 to date, can sometimes be repaired or rebuilt in a Service Shop. However, questions on this matter should be referred to the factory for recommendations.

APPARATUS 8.7-25 KV.

STANDARD TYPE A


Terminal stud
Gaskets compressed into recesses in metal
Washer
Transformer lead detachable at top of bushing for 400-amp rating
Holes for bolting bushing to apparatus cover
Washer
Terminal cap with 1⅛"–12 thread to accommodate line connector
Sealing nut
One-piece wet process porcelain shell
Cementless-type clamp

LOW CURRENT TYPE A

ADVANTAGES

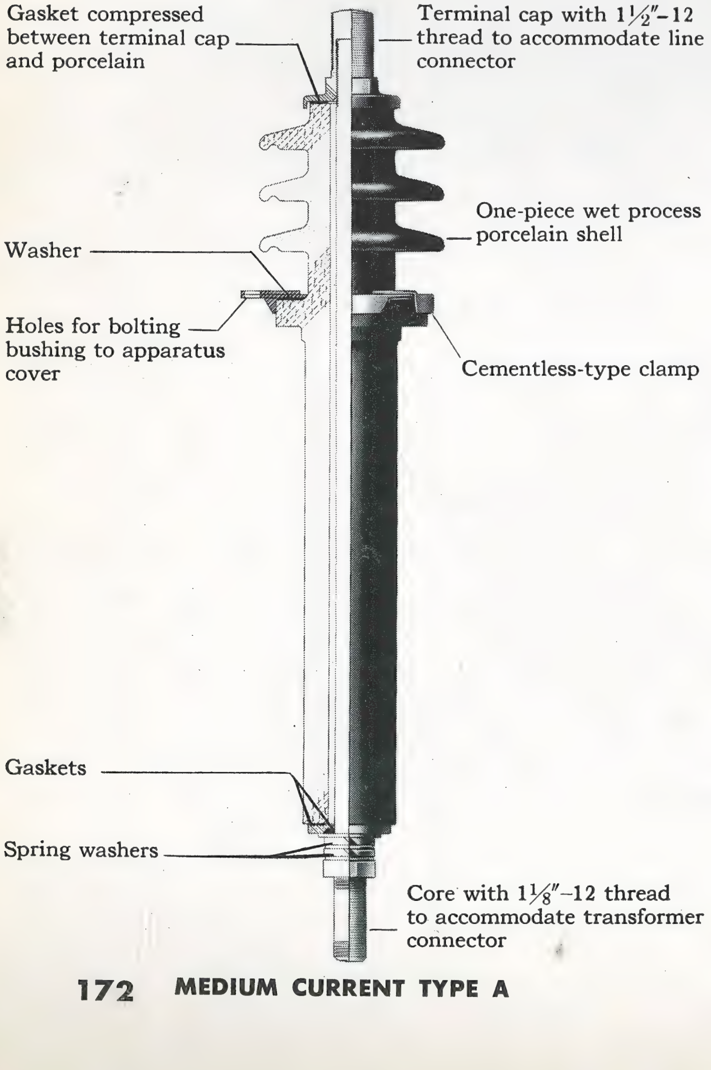
Type A bushings are of dry design and consist of rugged one-piece porcelain shells to which mounting hardware, conductor and terminals are attached. Their freedom of corona gives them excellent radio noise characteristics. Skilled electrical design of type A bushings assures their long life and full compliance with AIEE Standard requirements. They are easy to install and small overall dimensions make them particularly suitable for use on transformer covers where space is limited.

LOW CURRENT DESIGN

Pictured above, left, this design is for use at 400 amperes and below. The three-section mounting clamp is secured around the bushing by the same three bolts which fasten the bushing to the apparatus cover, eliminating the cement of older designs. Nitrile synthetic rubber gaskets seal the bushing from the atmosphere. Low current bushings are supplied with detachable cable accessories, which permit the use, inside the bushing, of a transformer cable lead, brazed to a cable terminal stud in the bushing cap. After removal of the cap, the transformer lead can be lowered through the bushing by means of a wire or cord, allowing bushing removal without access to the transformer interior.

MEDIUM CURRENT DESIGN

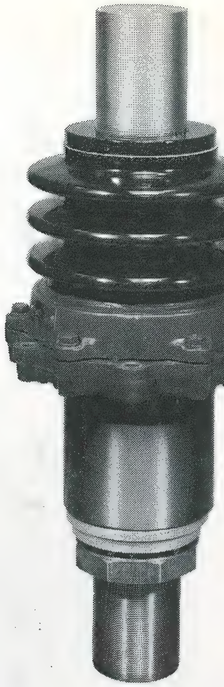
This design, for use at 1200 amperes is illustrated at left. It differs from low current bushings by the use of a central metal tube. The cap is threaded down on the central tube so that the porcelain is tightly pressed against the bottom assembly. This center clamping increases porcelain strength and assures pressure tightness of gasketed joints under all operating conditions. No liquid filler is used.


Gasket compressed between terminal cap and porcelain
Washer
Holes for bolting bushing to apparatus cover
Gaskets
Spring washers
Terminal cap with 1½"–12 thread to accommodate line connector
One-piece wet process porcelain shell
Cementless-type clamp
Core with 1⅛"–12 thread to accommodate transformer connector

MEDIUM CURRENT TYPE A

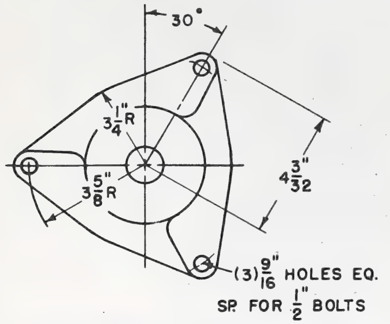
BUSHINGS

Since 1935, Locke Type A bushings have enjoyed an excellent service record. They are especially designed for use on power transformers in the 8.7 and 15 KV classes and on distribution transformers between 8.7 and 25 KV. They are adaptable to many other uses.

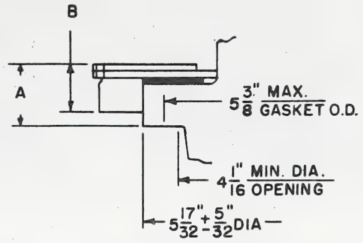


HIGH CURRENT DESIGN

Other designs, such as the one shown above, are available for over 1200 amperes. On request, bushings rated up to 7000 amperes can be supplied.


30°
3 1/4" R
3 5/8" R
4 3/32"
(3) 9/16" HOLES EQ. SP. FOR 1/2" BOLTS

ALIGNMENT VIEW


B
A
5 3/8" MAX. GASKET O.D.
4 1/16" MIN. DIA. OPENING
5 17/32" + 5/32" DIA

FLANGE DETAIL

FOR FIGS. 1 & 2

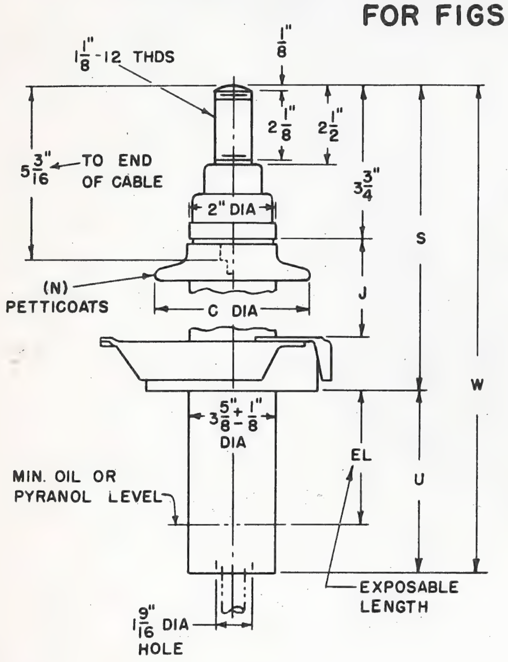

1 1/8"-12 THDS
1/8"
2 1/8"
2 1/2"
5 3/16" TO END OF CABLE
3 3/4"
2" DIA
(N) PETTICOATS
C DIA
J
S
W
3 5/8" + 1/8" DIA
MIN. OIL OR PYRANOL LEVEL
EL
U
EXPOSABLE LENGTH
1 9/16" DIA HOLE

FIGURE 1

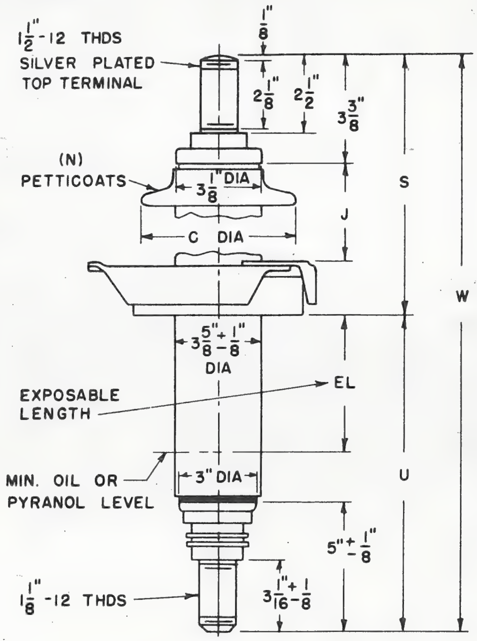

1 1/2"-12 THDS
SILVER PLATED TOP TERMINAL
1/8"
2 1/8"
2 1/2"
3 3/8"
(N) PETTICOATS
3 1/8" DIA
C DIA
J
S
W
3 5/8" + 1/8" DIA
EXPOSABLE LENGTH
EL
MIN. OIL OR PYRANOL LEVEL
3" DIA
U
5" + 1/8"
1 1/8" -12 THDS
3 1/16" + 1/8"

FIGURE 2

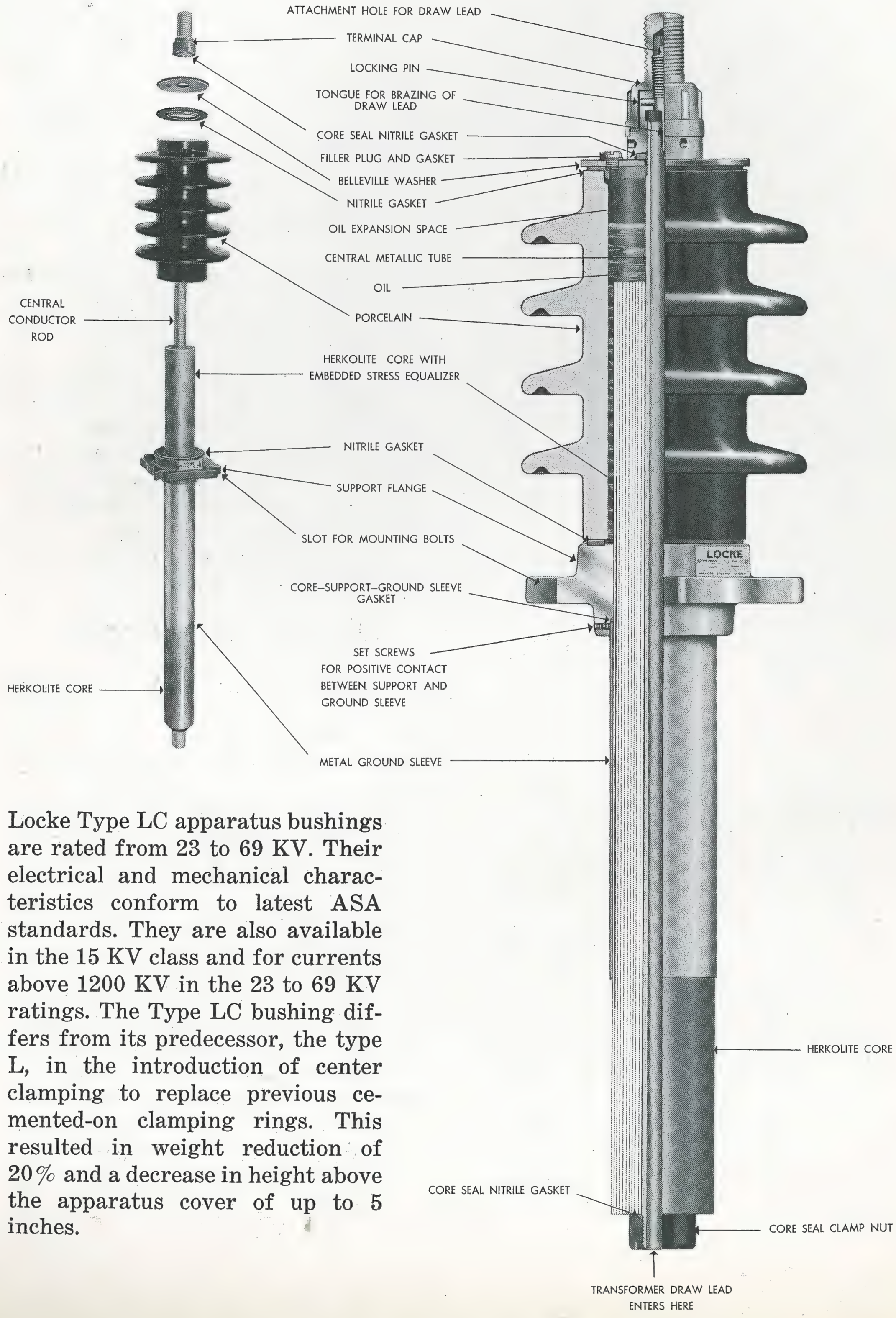
Class	Amps	Catalog Number	Fig. No.	Dimensions—Inches									Approx. Lbs. Net
				A	B	EL	C	J	N (No.)	U	S	W	
ADU8.7A	400	81747	1	15/16	13/16	0	4 3/4	4 15/16	2	4 3/4	10	14 3/4	15
ADU15A	400	81748	1	15/16	13/16	0	6	7 1/8	3	4 3/4	12 3/16	16 15/16	18
ADU8.7A	400	81749	1	15/16	13/16	17 3/4	4 3/4	4 15/16	2	18 3/8	10	28 3/8	20
ADU15A	400	81750	1	15/16	13/16	17 3/4	6	7 1/8	3	18 3/8	12 3/16	30 9/16	23
ADU8.7A	1200	81756	2	1 7/16	7/8	17 3/4	5 3/4	4 1/16	2	23 7/16	9 1/8	32 9/16	26
ADU15A	1200	81757	2	1 7/16	7/8	0	5 3/4	4 1/16	2	11 15/16	9 1/8	21 1/16	17
ADU8.7A	1200	81758	2	1 7/16	7/8	0	6 3/4	6 13/16	3	11 15/16	11 5/8	23 9/16	20
ADU15A	1200	81759	2	1 7/16	7/8	17 3/4	6 3/4	6 13/16	3	23 7/16	11 5/8	35 1/16	29

ASA STANDARD
TYPE LC
OIL FILLED

APPARATUS
23-69 KV.

DISASSEMBLED VIEW
TRANSFORMER OR OIL CIRCUIT BREAKER BUSHING
34.5 KV—1200 AMP.

CUT-AWAY VIEW
TRANSFORMER BUSHING
23 KV—400 AMP.


ATTACHMENT HOLE FOR DRAW LEAD
TERMINAL CAP
LOCKING PIN
TONGUE FOR BRAZING OF DRAW LEAD
CORE SEAL NITRILE GASKET
FILLER PLUG AND GASKET
BELLEVILLE WASHER
NITRILE GASKET
OIL EXPANSION SPACE
CENTRAL METALLIC TUBE
OIL
CENTRAL CONDUCTOR ROD
PORCELAIN
HERKOLITE CORE WITH EMBEDDED STRESS EQUALIZER
NITRILE GASKET
SUPPORT FLANGE
SLOT FOR MOUNTING BOLTS
CORE-SUPPORT-GROUND SLEEVE GASKET
SET SCREWS FOR POSITIVE CONTACT BETWEEN SUPPORT AND GROUND SLEEVE
HERKOLITE CORE
METAL GROUND SLEEVE
LOCKE
HERKOLITE CORE
CORE SEAL NITRILE GASKET
CORE SEAL CLAMP NUT
TRANSFORMER DRAW LEAD ENTERS HERE

Locke Type LC apparatus bushings are rated from 23 to 69 KV. Their electrical and mechanical characteristics conform to latest ASA standards. They are also available in the 15 KV class and for currents above 1200 KV in the 23 to 69 KV ratings. The Type LC bushing differs from its predecessor, the type L, in the introduction of center clamping to replace previous cemented-on clamping rings. This resulted in weight reduction of 20% and a decrease in height above the apparatus cover of up to 5 inches.

BUSHINGS 400-1200 AMP

VALUABLE FEATURES

CENTER CLAMPING STRENGTHENS PORCELAIN

The rugged porcelain is firmly clamped between the metal support flange and a Belleville spring washer which serves as cover plate. As the support flange and metal ground sleeve are solidly bonded to the Herkolite core, the bushing forms a rigid unit. The heavy bronze Belleville washer, originally dish-shaped, is flattened as the bushing is compressed, and later maintains compression during dimensional changes due to heating or cooling (see photo, page 29).

SERVICE-PROVEN CORE CONSTRUCTION

Proved in previous designs, the resin-impregnated Herkolite insulation, wound around the central conductor, possesses high dielectric and mechanical strength. A conducting Rescon paint layer, placed within the Herkolite, acts as voltage stress equalizer (see photo p. 28). The space between the upper portion of the core and the porcelain is filled with 10C insulating oil. Ample space is allowed for oil expansion.

COMPLETE SEALING AGAINST MOISTURE

Permanent-type Nitrile gaskets, porcelain surfaces ground perfectly true, machined metal parts, the compression of the Belleville spring washer . . . all these assure dependable sealing of the bushing against outside moisture. (If the screw in the Belleville washer is removed in service for access to the oil, care must be taken to use a new gasket for proper sealing.)

The following features make the bushing pressure-tight against loss of liquid and gas in a transformer, even in case of accidental porcelain breakage:

1. The tubular ground sleeve is pressed over the accurately machined Herkolite, placing the tube in tension for a liquid-tight joint. Tests on a 69 KV bushing core required a force of over 40,000 lbs. to cause slippage of the sleeve on the core (photo, page 28).

2. Gaskets are compressed in recesses in the Herkolite (between ground sleeve and support flange) and in the bushing cap (between conductor tube and bushing cap).

3. A clamp nut and Nitrile gasket at the bottom of the core give further protection against leakage.

DETACHABLE CABLE UP TO 400 AMPS

Detachable cable accessories permit the use, inside the conductor tube, of a transformer cable lead, attached to a cable terminal stud in the bushing top. After removal of the cap, the transformer lead can be lowered through the bushing by means of a wire or cord, allowing bushing removal without access to the transformer interior. Above 400 amperes, central tubes or rods are used as conductors. Transformer leads are connected to their threaded bottom ends.

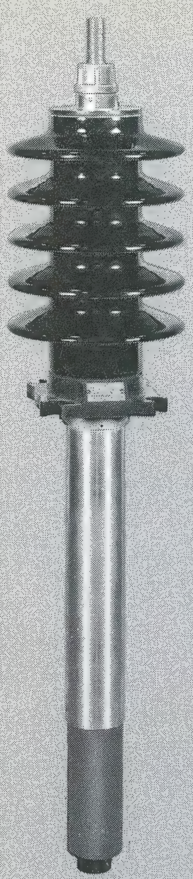
TESTED AT THE FACTORY

Quality control tests during manufacture include a Freon "sniff" test to detect the slightest fault in sealing (see photo, page 29). Exhaustive electrical tests according to AIEE Standards include withstand tests, checks of power factor and capacitance. Radio noise meters check that the bushing is within the NEMA radio noise level.

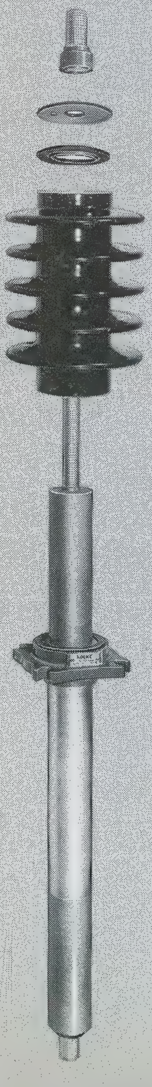
REPLACEMENTS

Special LC bushings are available for replacing corresponding type S and L bushings of superseded design. Their support flange dimensions are identical with those of older bushings and other dimensions are as close as permitted by the improved design. The reduced height of the replacement may require shortening of the detachable cable conductor on 400 amperes bushings and lengthening of line lead connections.

APPARATUS
23-69 KV.



ASA STANDARD
TYPE LC
OIL FILLED



ADVANTAGES

1. The Locke type LC bushing conforms to applicable ASA electrical and mechanical standards.

2. Center clamping develops full porcelain strength and reduces possibility of porcelain breakage, even if the bushing flange is tightened unevenly.

3. Completely sealed. Requires only periodic inspection and cleaning of porcelain. Can be handled freely, as the liquid cannot be spilled.

4. Extremely easy to rebuild in the field in case of porcelain damage—even in place on the transformer.

5. Liquid filling prevents entrapping of air and the formation of voids or cracks in the core. This prevents corona discharges under high stress.

6. Initial high dielectric strength is maintained by completely sealed construction which prevents entrance of air or moisture.

7. Initial low power factor of the bushing remains low in service, giving assurance that the bushing is free from deterioration.

8. Corona free, the bushing has exceptionally satisfactory radio-influence voltage characteristics.

Former Standard Type LC, see pages 185-186.

BUSHINGS
400-1200 AMP

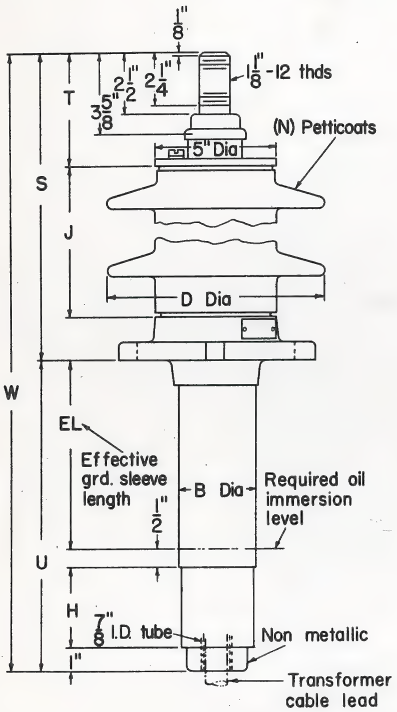
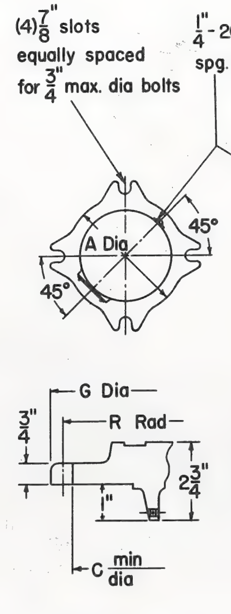
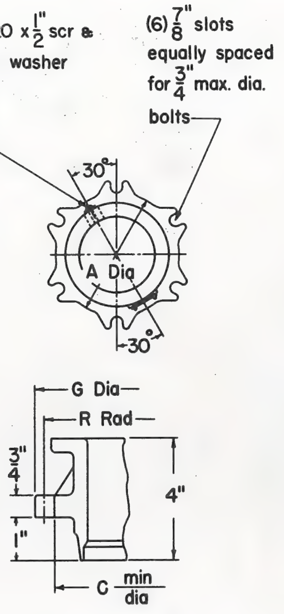

1/8"
T
2 1/2"
2 1/4"
3 5/8"
1 1/8"-12 thds
5" Dia
(N) Petticoats
S
J
D Dia
W
EL
Effective grd. sleeve length
B Dia
Required oil immersion level
1/2"
U
H
7/8" I.D. tube
Non metallic
1"
Transformer cable lead

Fig. 1


(4) 7/8" slots equally spaced for 3/4" max. dia bolts
1/4"-20 x 1/2" scr & spg. washer
45°
A Dia
45°
G Dia
R Rad
3/4"
2 3/4"
1"
C min dia

Flange Detail
Fig.-3


(6) 7/8" slots equally spaced for 3/4" max. dia. bolts
30°
A Dia
30°
G Dia
R Rad
3/4"
4"
1"
C min dia

Flange Detail
Fig.-4

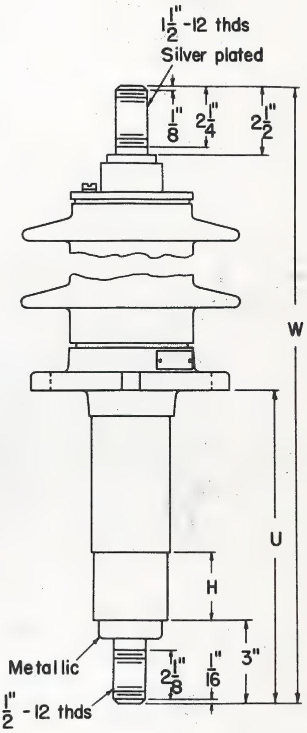

1 1/2"-12 thds Silver plated
1/8"
2 1/4"
2 1/2"
W
U
H
3"
Metallic
2 1/8"
1/16"
1 1/2"-12 thds

Fig.-2

Class	Ampere	Catalog Number	Dimensions—Inches															Min. Dia. Open'g. In.	Fig. No.
			A	B	C	D	EL	G	H	J	N No.	R	S	T	U	W		
A23	400	815001	6⅜	2¾	6¼	8½	10	8⅛	5	9 3/16	4	3⅝	16	5 1/16	16½	32½	4	1 & 3
	400	815002	6⅜	2¾	6¼	8½	16½	8⅛	5	9 3/16	4	3⅝	16	5 1/16	23	39	4	1 & 3
	400	815003	6⅜	2¾	6¼	8½	21	8⅛	5	9 3/16	4	3⅝	16	5 1/16	27½	43½	4	1 & 3
	1200	815014	6⅜	2¾	6¼	8½	21	8⅛	6	9 3/16	4	3⅝	15⅛	4 3/16	30½	45⅝	4	2 & 3
	1200	815015	6⅜	2¾	6¼	8½	27	8⅛	6	9 3/16	4	3⅝	15⅛	4 3/16	36½	51⅝	4	2 & 3
*H23	1200	815013	6⅜	2¾	6¼	8½	16½	8⅛	9½	9 3/16	4	3⅝	15⅛	4 3/16	29½	44⅝	4	2 & 3
A34.5	400	815004	6⅜	3⅛	6¼	9⅜	10	8⅛	7	13 13/16	5	3⅝	20⅝	5 1/16	18½	39⅛	4	1 & 3
	400	815005	6⅜	3⅛	6¼	9⅜	16½	8⅛	7	13 13/16	5	3⅝	20⅝	5 1/16	25	45⅝	4	1 & 3
	400	815006	6⅜	3⅛	6¼	9⅜	21	8⅛	7	13 13/16	5	3⅝	20⅝	5 1/16	29½	50⅛	4	1 & 3
	1200	815017	6⅜	3⅛	6¼	9⅜	21	8⅛	8	13 13/16	5	3⅝	19¾	4 3/16	32½	52¼	4	2 & 3
	1200	815018	6⅜	3⅛	6¼	9⅜	27	8⅛	8	13 13/16	5	3⅝	19¾	4 3/16	38½	58¼	4	2 & 3
*H34.5	1200	815016	6⅜	3⅛	6¼	9⅜	16½	8⅛	11½	13 13/16	5	3⅝	19¾	4 3/16	31½	51¼	4	2 & 3
A46	400	815007	7⅜	3¾	7¼	9½	10	9⅛	9	18 11/16	8	4⅛	25½	5 1/16	20½	46	5	1 & 3
	400	815008	7⅜	3¾	7¼	9½	16½	9⅛	9	18 11/16	8	4⅛	25½	5 1/16	27	52½	5	1 & 3
	400	815009	7⅜	3¾	7¼	9½	21	9⅛	9	18 11/16	8	4⅛	25½	5 1/16	31½	57	5	1 & 3
	1200	815020	7⅜	3¾	7¼	9½	21	9⅛	10	18 11/16	8	4⅛	24⅝	4 3/16	34½	59⅛	5	2 & 3
	1200	815021	7⅜	3¾	7¼	9½	27	9⅛	10	18 11/16	8	4⅛	24⅝	4 3/16	40½	65⅛	5	2 & 3
*H46	1200	815019	7⅜	3¾	7¼	9½	16½	9⅛	13½	18 11/16	8	4⅛	24 11/16	4¼	33½	58 3/16	5	2 & 3
A69	400	815060	8⅜	5¼	8¼	12¼	16½	10⅝	12½	27 3/16	8	4⅝	36⅞	6 11/16	30½	67⅜	6	1 & 4
	400	815061	8⅜	5¼	8¼	12¼	21	10⅝	12½	27 3/16	8	4⅝	36⅞	6 11/16	35	71⅞	6	1 & 4
	400	815062	8⅜	5¼	8¼	12¼	27	10⅝	12½	27 3/16	8	4⅝	36⅞	6 11/16	41	77⅞	6	1 & 4
	1200	815073	8⅜	5¼	8¼	12¼	21	10⅝	13½	27 3/16	8	4⅝	36⅝	6 7/16	38	74⅝	6	2 & 4
	1200	815074	8⅜	5¼	8¼	12¼	27	10⅝	13½	27 3/16	8	4⅝	36⅝	6 7/16	44	80⅝	6	2 & 4
*H69	1200	815072	8⅜	5¼	8¼	12¼	16½	10⅝	17½	27 3/16	8	4⅝	36⅝	6 7/16	37½	74⅛	6	2 & 4

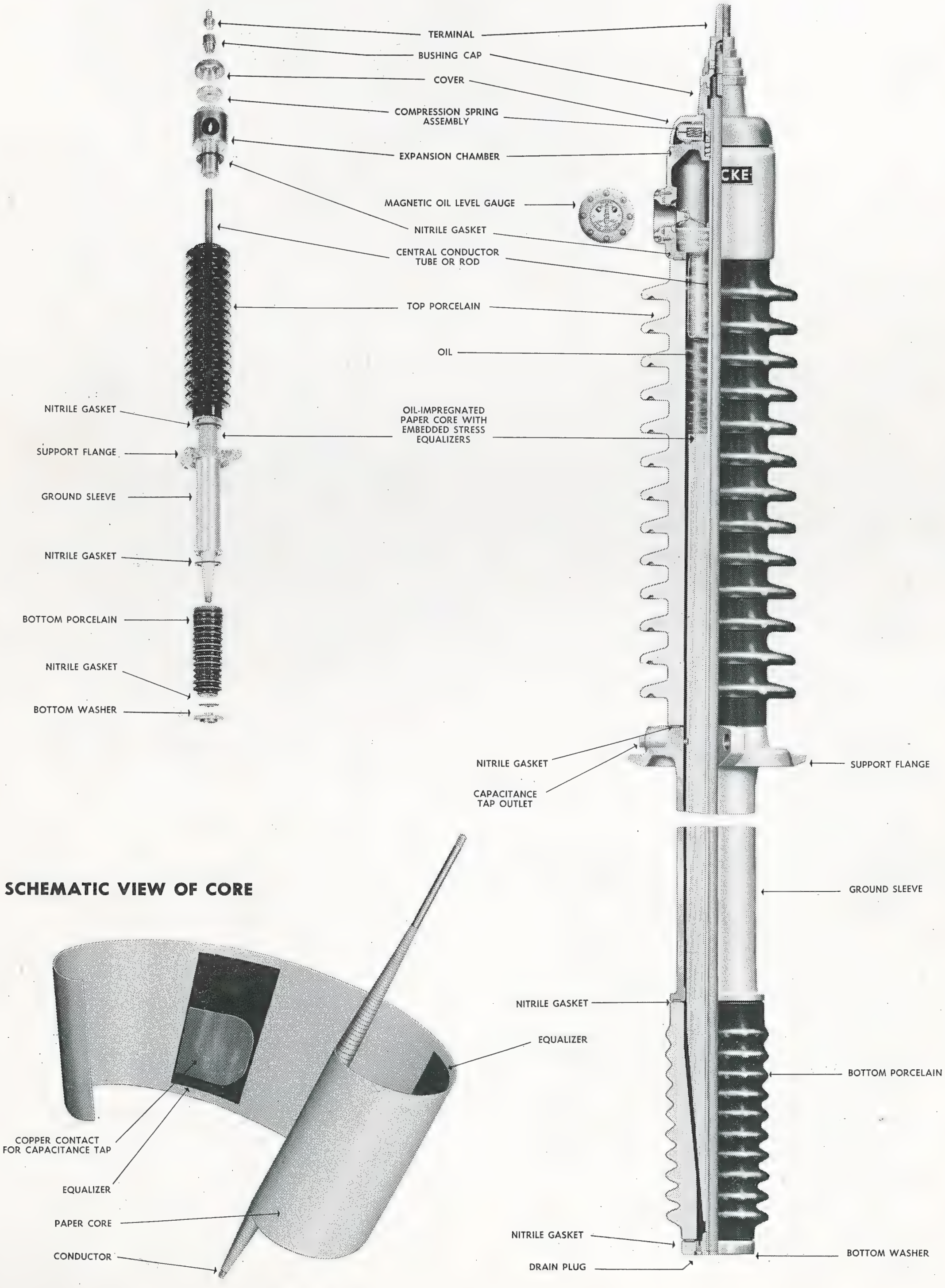
* Bottom of rod has silver plated contact surfaces.

APPARATUS
115-330 KV

DISASSEMBLED VIEW
OIL CIRCUIT BREAKER BUSHING

CUT-AWAY VIEW
TRANSFORMER BUSHING

SCHEMATIC VIEW OF CORE


TERMINAL
BUSHING CAP
COVER
COMPRESSION SPRING ASSEMBLY
EXPANSION CHAMBER
MAGNETIC OIL LEVEL GAUGE
NITRILE GASKET
CENTRAL CONDUCTOR TUBE OR ROD
TOP PORCELAIN
OIL
OIL-IMPREGNATED PAPER CORE WITH EMBEDDED STRESS EQUALIZERS
NITRILE GASKET
SUPPORT FLANGE
GROUND SLEEVE
NITRILE GASKET
BOTTOM PORCELAIN
NITRILE GASKET
BOTTOM WASHER
CKE
NITRILE GASKET
CAPACITANCE TAP OUTLET
SUPPORT FLANGE
GROUND SLEEVE
NITRILE GASKET
EQUALIZER
BOTTOM PORCELAIN
COPPER CONTACT FOR CAPACITANCE TAP
EQUALIZER
PAPER CORE
CONDUCTOR
NITRILE GASKET
DRAIN PLUG
BOTTOM WASHER

BUSHINGS

STANDARD TYPE U OIL FILLED

Sealed, oil-filled Locke Type U Bushings are designed for power, distribution and instrument transformers and oil circuit breakers rated from 115 to 330 KV. The use of oil-impregnated paper cores with embedded voltage stress equalizers gives these bushings the desirable electrical characteristics of their predecessors—the OF and F bushings—with the additional advantages of lightness and smaller size.

VALUABLE FEATURES

INTERNAL CONSTRUCTION

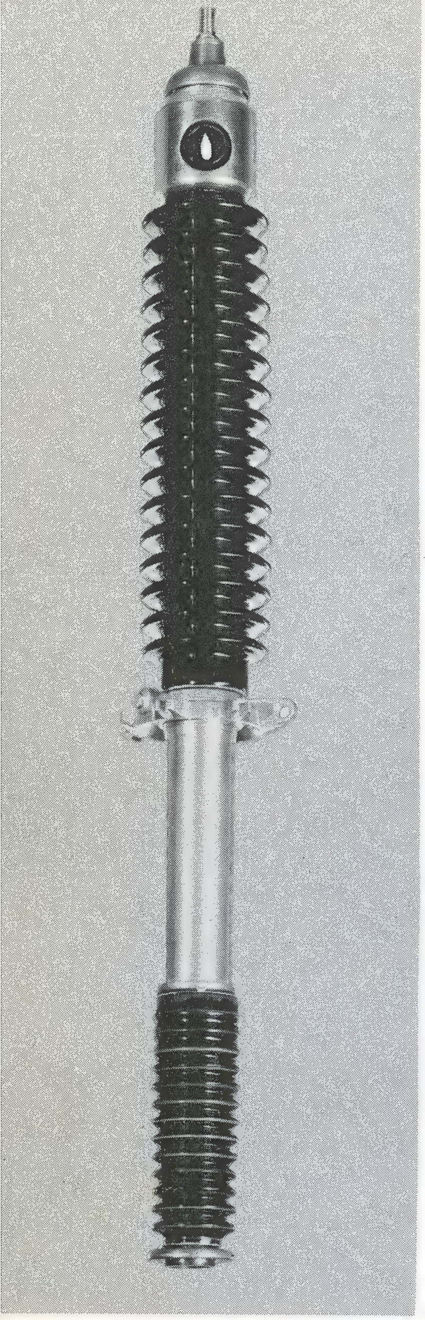
Uniform internal voltage gradients and controlled external voltage distribution are achieved in the Type U bushing by the unique construction of its core. The central metal conductor or tube is wound with carefully inspected Kraft paper, which is later thoroughly impregnated with the filling oil of the bushing (see photo, page 30). During the winding of this core, voltage stress equalizers in the form of bands of conducting Rescon paint are applied. The dimensions and total number of these bands, as well as the intervals between them, are precisely determined in advance for optimum distribution of voltage gradients between conductor and grounded flange. The tangible result of this design is the elimination of internal corona and its harmful consequences in the operation of the bushing.

CENTER CLAMPING AND ATMOSPHERIC SEAL

The two one-piece porcelains of the Type U bushing are held in tight compression—the upper one between the support flange and the metal oil expansion chamber, the lower one between the ground sleeve (which is integral with the support flange) and the bottom washer. While Nitrile synthetic rubber gaskets maintain a pressure-tight and moisture-proof seal, a multiple coil spring assembly arranged concentrically around the central conductor above the expansion chamber maintains constant pressure during dimensional changes due to heating and cooling (see photo, page 30). The compression of up to 30,000 lbs.—depending on bushing size—is of great value in maintaining required gasket compression, alignment stability and highest porcelain strength to withstand operating shocks. The magnetic liquid level gage accurately indicates bushing oil level without danger of leaks even if the glass dial cover is broken. As the bushing is completely sealed, it requires no internal servicing, unless the gage indicates low oil level.

GROUND SLEEVE

The ground sleeve which is an integral part of the support flange, provides a surface at the potential of the apparatus cover, which makes the bushing ideally adapted for use in equipment with air or gas space above the insulating liquid and for use with bushing-type current transformers. The ground sleeve, whose lower end should always be immersed at least one-half inch in the insulating liquid of the apparatus, brings ground potential to the surface of this liquid and effectively short circuits the space between liquid and apparatus cover. This eliminates the danger of internal electrical discharges in the apparatus.



Ask your nearest Locke representative to demonstrate this 1/6 scale model of a Type U bushing.

APPARATUS
115-330 KV

STANDARD
TYPE U
OIL FILLED

DETACHABLE CABLE UP TO 800 AMPS

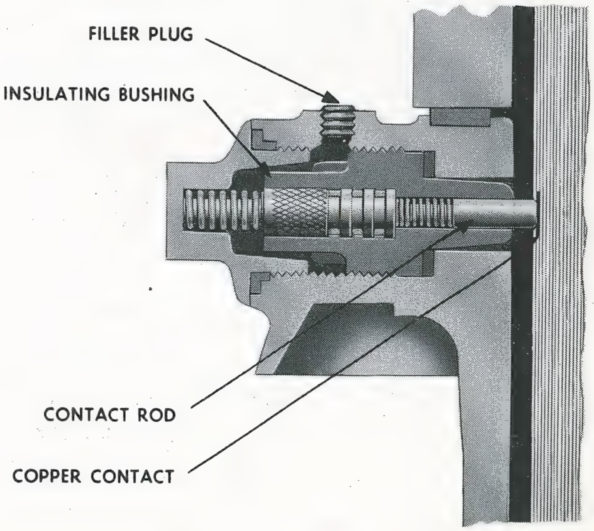
Type U transformer bushings rated 69 to 330 KV inclusive, for currents up to 800 amperes inclusive (except to 400 amperes for 69 KV bushings), are designed for the use of a transformer cable lead inside the central tube. This lead is detachable at the terminal cap and can be raised or lowered through the central tube when installing or removing the bushing, so that servicing or replacement can be accomplished without entering the apparatus. For higher currents and all oil circuit breaker applications, the central tube or rod serves as the conductor, connections being made at the ends of the bushing.

DRAIN PLUG IN BOTTOM WASHER

For the removal of an oil sample from the bushing, a drain plug is located in the side of the bottom washer of circuit breaker bushings. This makes it unnecessary to disconnect circuit breaker interrupter parts for opening of the drain plug. On transformer bushings, the drain plug is in the underside of the bottom washer.

PROVISIONS FOR OIL CIRCUIT BREAKER USE

The rigid, center clamped design makes Type U bushings highly desirable for use in oil circuit breakers. For such applications, the bottom washer is furnished with tapped holes and an annular line contact bottom surface to provide for attachment and alignment of the circuit breaker contact. The lower porcelain is covered with a special glaze, developed by Locke, which inhibits the deposition of carbon on the porcelain and maintains high electrical creepage while submerged in the circuit breaker liquid.



CAPACITANCE TAP DETAIL

BUSHINGS

CAPACITANCE TAP IS STANDARD FEATURE

To provide a voltage supply for potential devices, all Type U bushings are built with a capacitance tap, connected to a conducting electrode, embedded in the paper core. The capacitance tap is a convenient means of making power factor measurements and serves as a connection to potential devices. A spring loaded plunger assures positive contact with the copper foil electrode in the core.

CAUTION

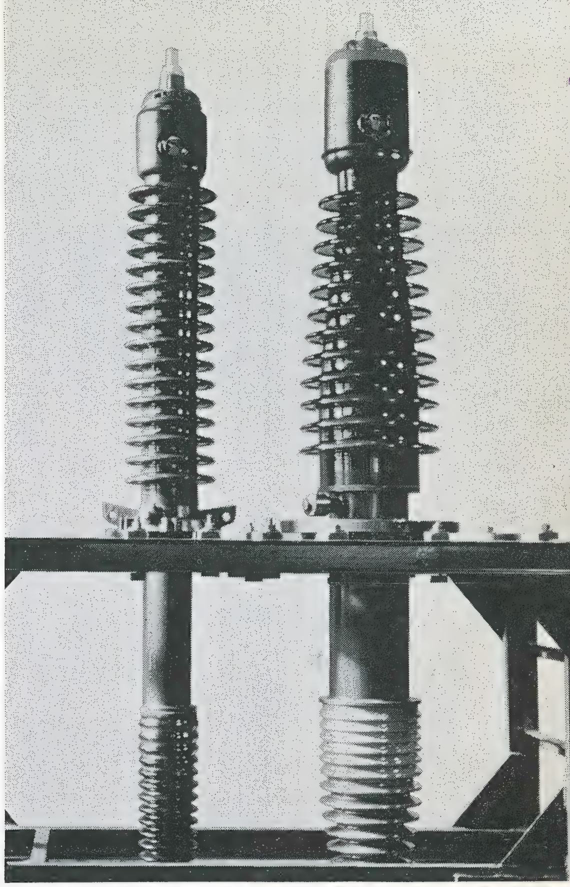
Transformer bushings are shipped without oil in the tap chamber, as they are not normally used with potential devices. If the tap is opened, it is vital to replace the grounding spring before replacing the cover. If a potential device is attached, the chamber must be filled with #219 compound.

On circuit breaker bushings, the capacitance tap is filled with #219 compound at the factory. Additional compound is supplied with the potential device cable. In opening the tap, when attaching a potential device, the compound is lost and must be replaced before energizing the bushing. When potential device is not used, the grounding spring must be replaced.

ADVANTAGES

1. Lighter weight and smaller diameter are made possible by the oil-impregnated paper core with embedded voltage stress equalizers.

2. Permanent high dielectric strength of the core is assured, because the Type U bushing is completely sealed against entrance of air or moisture.



Note how much the Type-U bushing differs from the older Type F, shown at the right. While both are 138 KV bushings, the Type U is 5⅝" smaller in ground sleeve diameter and 415 lbs. lighter.

3. The initial power factor of nearly zero remains low in service, giving assurance that the bushing is in good condition and free of deterioration.

4. Capacitance tap is a standard feature, providing a voltage supply for potential devices and simplifying power factor testing.

5. The insulating oil is protected by a metal expansion chamber against the deteriorating effects of sunlight. A magnetic liquid-level gage provides accurate indication of the oil level in the bushing without danger of entrance of moisture even if the dial glass is broken.

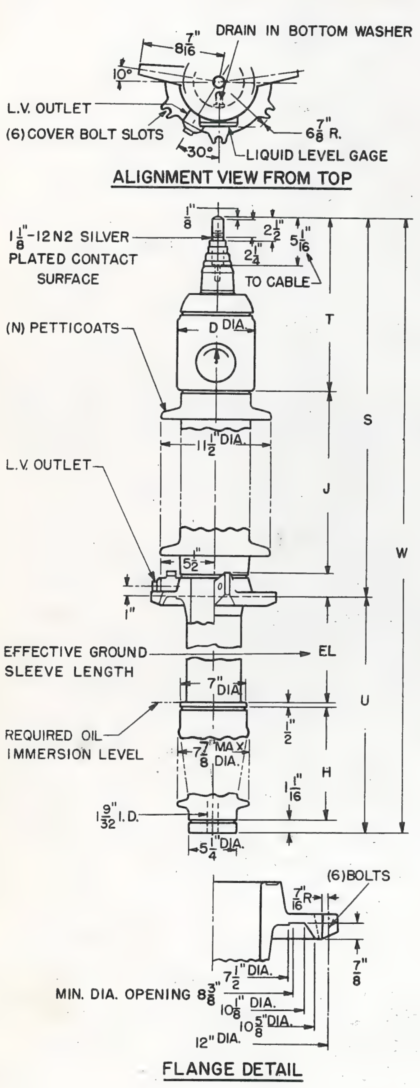
6. The Type U bushing may be used to replace either the OF or F bushing in any standard apparatus application. Adapters can be furnished with replacement bushings.

7. Corona free, the bushing has exceptionally satisfactory radio-influence characteristics.

8. Always ready for installation, Type U bushings require no servicing other than periodic inspection and cleaning of porcelain surfaces.

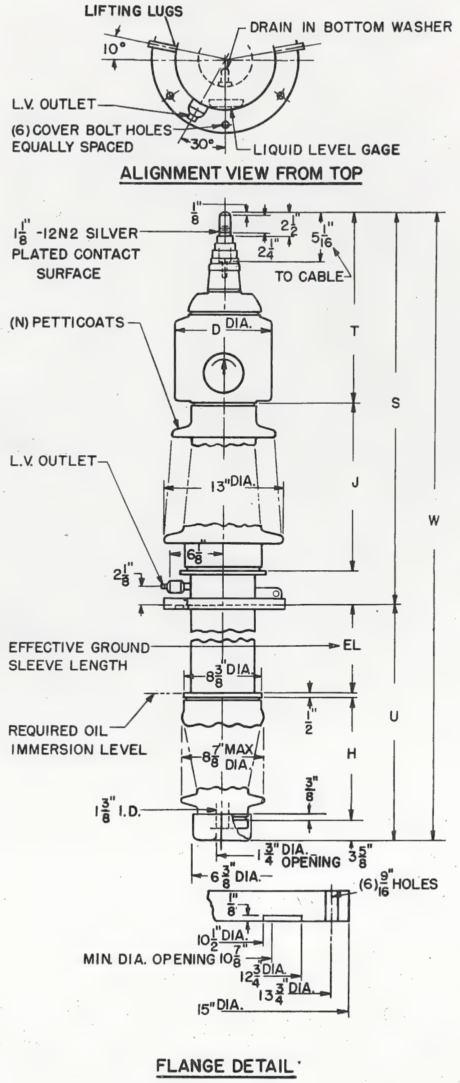
APPARATUS
115-330 KV.

TYPE U
FOR TRANSFORMERS



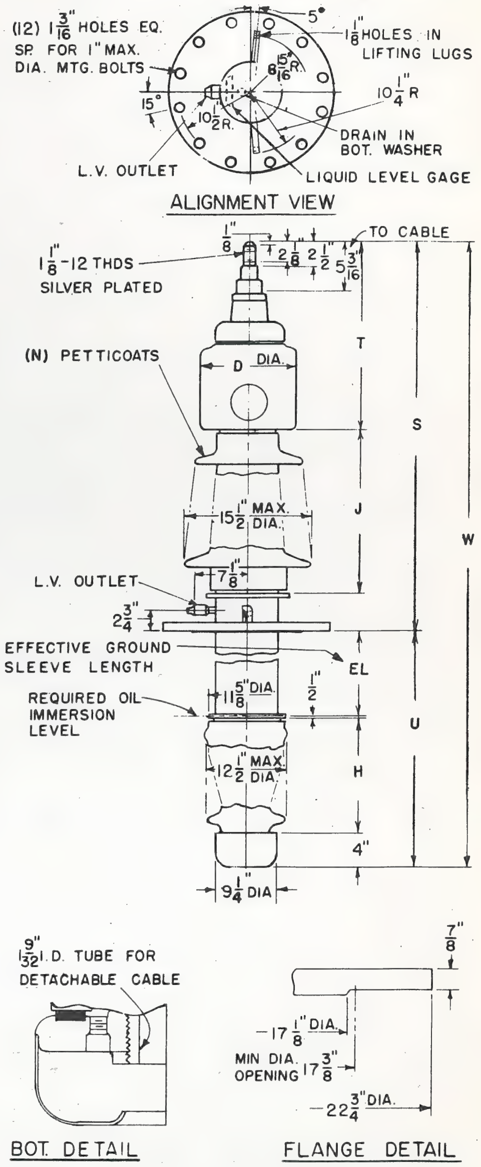
8 7/16"
DRAIN IN BOTTOM WASHER
10°
L.V. OUTLET
(6) COVER BOLT SLOTS
6 7/8" R.
30°
LIQUID LEVEL GAGE
ALIGNMENT VIEW FROM TOP
1/8"
1 1/8"-12N2 SILVER PLATED CONTACT SURFACE
2 1/2"
5 1/16"
2 1/4"
TO CABLE
(N) PETTICOATS
D DIA.
T
S
11 1/2" DIA.
L.V. OUTLET
J
W
5 1/2"
1"
EFFECTIVE GROUND SLEEVE LENGTH
EL
7" DIA.
U
REQUIRED OIL IMMERSION LEVEL
1/2"
7 7/8" MAX. DIA.
H
1 1/16"
1 9/32" I.D.
5 1/4" DIA.
(6) BOLTS
7/16" R.
7/8"
7 1/2" DIA.
MIN. DIA. OPENING 8 3/8"
10 1/8" DIA.
10 5/8" DIA.
12" DIA.
FLANGE DETAIL

FIGURE 1



LIFTING LUGS
DRAIN IN BOTTOM WASHER
10°
L.V. OUTLET
(6) COVER BOLT HOLES EQUALLY SPACED
30°
LIQUID LEVEL GAGE
ALIGNMENT VIEW FROM TOP
1/8"
1 1/8" -12N2 SILVER PLATED CONTACT SURFACE
2 1/2"
5 1/16"
2 1/4"
TO CABLE
(N) PETTICOATS
D DIA.
T
S
L.V. OUTLET
13" DIA.
J
W
6 5/8"
2 1/8"
EFFECTIVE GROUND SLEEVE LENGTH
EL
8 3/8" DIA.
REQUIRED OIL IMMERSION LEVEL
1/2"
U
8 7/8" MAX DIA.
H
3/8"
1 3/8" I.D.
1 3/4" DIA. OPENING
3 5/8"
6 3/8" DIA.
(6) 9/16" HOLES
1/8"
10 1/2" DIA.
MIN. DIA. OPENING 10 7/8"
12 3/4" DIA.
13 3/4" DIA.
15" DIA.
FLANGE DETAIL

FIGURE 2



(12) 1 3/16" HOLES EQ. SP. FOR 1" MAX. DIA. MTG. BOLTS
5°
1 1/8" HOLES IN LIFTING LUGS
8 15/16" R.
10 1/4" R
15°
10 1/2 R.
DRAIN IN BOT. WASHER
L.V. OUTLET
LIQUID LEVEL GAGE
ALIGNMENT VIEW
1/8"
TO CABLE
1 1/8"-12 THDS SILVER PLATED
2 1/8"
2 1/2"
5 3/16"
(N) PETTICOATS
D DIA.
T
S
15 1/2" MAX. DIA.
J
W
L.V. OUTLET
7 1/8"
2 3/4"
EFFECTIVE GROUND SLEEVE LENGTH
EL
1/2"
REQUIRED OIL IMMERSION LEVEL
11 5/8" DIA.
U
12 1/2" MAX. DIA.
H
4"
9 1/4" DIA
1 9/32" I.D. TUBE FOR DETACHABLE CABLE
BOT. DETAIL
7/8"
17 1/8" DIA.
MIN DIA. OPENING 17 3/8"
22 3/4" DIA.
FLANGE DETAIL

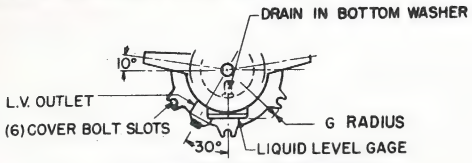
FIGURE 3

Class	Ampere	Catalog Number	Fig. No.	N	Dimensions—Inches								Approx. Net Wt. Filled in Lbs.	Approx. Capac. Gallons
					D	H	J	EL	S	T	U	W		
AJ115	800	86812	1	13	9	17 7/8	35 13/16	13 3/4	56 9/16	19 1/4	33 3/16	89 3/4	255	3 1/4
	800	86822	1	13	9	17 7/8	35 13/16	26 3/4	56 9/16	19 1/4	46 3/16	102 3/4	265	4 1/4
AJ138	800	86813	1	16	9	21 5/8	43 1/8	13 3/4	64 1/2	19 1/4	36 15/16	101 7/16	260	5
	800	86823	1	16	9	21 5/8	43 1/8	26 3/4	64 1/2	19 1/4	49 15/16	114 7/16	295	5 1/2
AJ161	800	86814	2	19	10 1/4	25 1/8	51 3/16	13 3/4	76 1/8	20 11/16	43	119 1/8	335	7
	800	86824	2	19	10 1/4	25 1/8	51 3/16	26 3/4	76 1/8	20 11/16	56	132 1/8	350	7 3/4
AJ196	800	87656	3	23	11 7/8	30 5/8	63 7/16	26 3/4	97 1/4	26 15/16	61 7/8	159 1/8	1000	9

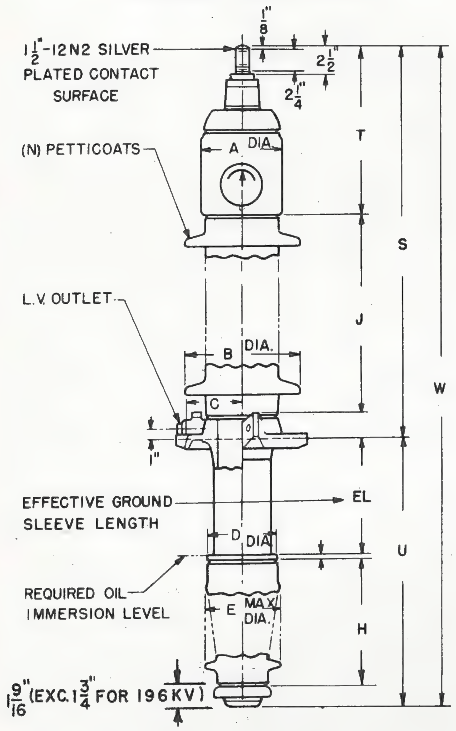
BUSHINGS

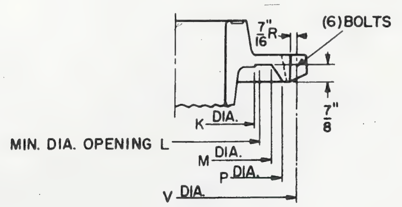
TYPE U
FOR CIRCUIT BREAKERS

Type U bushings above 196 KV are not illustrated on these pages. Bushings for service up to 330 KV have been built. Detailed specifications are available on request.

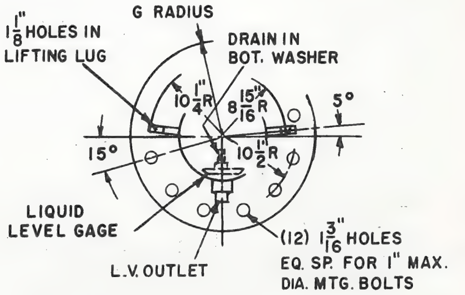

DRAIN IN BOTTOM WASHER
10°
L.V. OUTLET
(6) COVER BOLT SLOTS
30°
G RADIUS
LIQUID LEVEL GAGE

ALIGNMENT VIEW FROM TOP

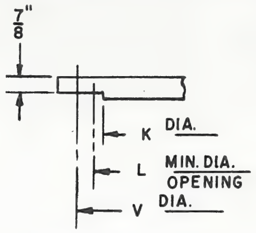

1/8"
1 1/2"-12N2 SILVER PLATED CONTACT SURFACE
2 1/2
2 1/4"
(N) PETTICOATS
A DIA.
T
S
W
L.V. OUTLET
J
B DIA.
C
1"
EFFECTIVE GROUND SLEEVE LENGTH
EL
D DIA.
U
REQUIRED OIL IMMERSION LEVEL
E MAX. DIA.
H
1 9/16"(EXC. 1 3/4" FOR 196 KV)


7/16"R
(6) BOLTS
7/8"
K DIA.
MIN. DIA. OPENING L
M DIA.
P DIA.
V DIA.

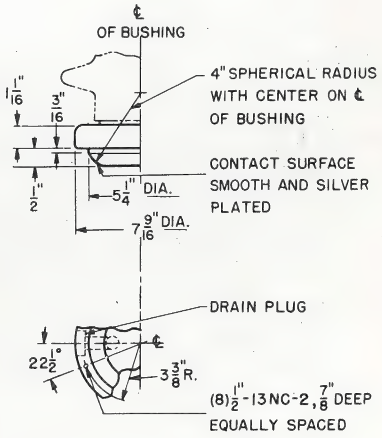
FLANGE DETAIL (115-161 KV)


G RADIUS
1 1/8" HOLES IN LIFTING LUG
DRAIN IN BOT. WASHER
10 1/4"R
8 15/16"R
5°
15°
10 1/2"R
LIQUID LEVEL GAGE
L.V. OUTLET
(12) 1 3/16" HOLES EQ. SP. FOR 1" MAX. DIA. MTG. BOLTS

ALIGNMENT VIEW (196 KV)


7/8"
K DIA.
L MIN. DIA. OPENING
V DIA.

FLANGE DETAIL (196KV)

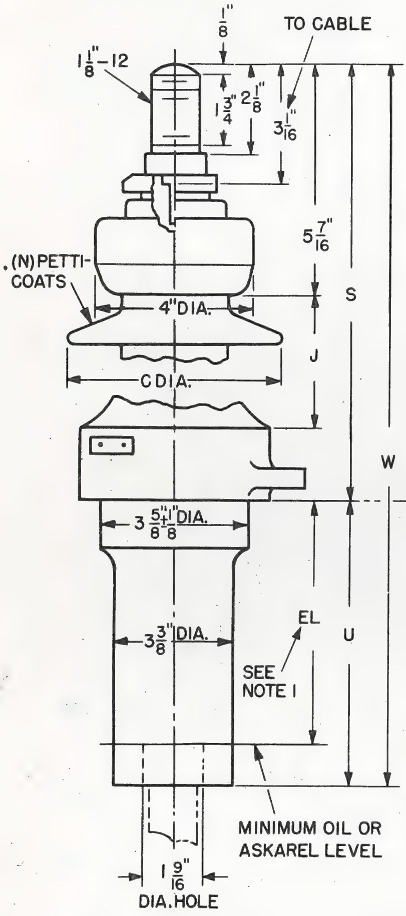

℄ OF BUSHING
4" SPHERICAL RADIUS WITH CENTER ON ℄ OF BUSHING
1 1/16"
3/16"
1/2"
5 1/4" DIA.
CONTACT SURFACE SMOOTH AND SILVER PLATED
7 9/16" DIA.
DRAIN PLUG
℄
22 1/2°
3 3/8"R.
(8) 1/2"-13NC-2, 7/8" DEEP EQUALLY SPACED

BOTTOM WASHER DETAILS

Class	Ampere	Catalog Number	N	Dimensions—Inches																		Approx. Net Wt. Filled, in Lbs.	Approx. Capac. Gallons
				A	B	C	D	E	EL	G	H	J	K	L	M	P	S	T	U	V	W		
BJ115	1200	86802	13	8	11½	5½	7	7¾	23	6⅞	17⅞	35 3/16	7½	8	9⅝	10⅝	54 3/16	16⅞	43	12	96 3/16	250	4
BJ138	1200	86803	16	9	11½	5½	7	7⅞	23	6⅞	21⅝	43⅛	7½	8	9⅝	10⅝	62⅛	16⅞	46¾	12	108⅞	285	5
BJ161	1200	87484	19	10¼	13	6	8⅜	8 15/16	23	7½	25⅛	51 3/16	9⅝	9¾	11⅜	12⅜	73½	19 7/16	50¼	14	123¾	500	8
BJ161	1600	86804	19	10¼	13	6	8⅜	8 15/16	23	7½	25⅛	51 3/16	9⅝	9¾	11⅜	12⅜	73½	19 7/16	50¼	14	123¾	500	8
BJ196	1600	87654	23	11⅞	15½	7⅛	11⅝	12½	26¾	11⅜	30⅝	63 7/16	17⅛	17⅜	—	—	94½	24 3/16	59⅝	21	154⅛	1025	9

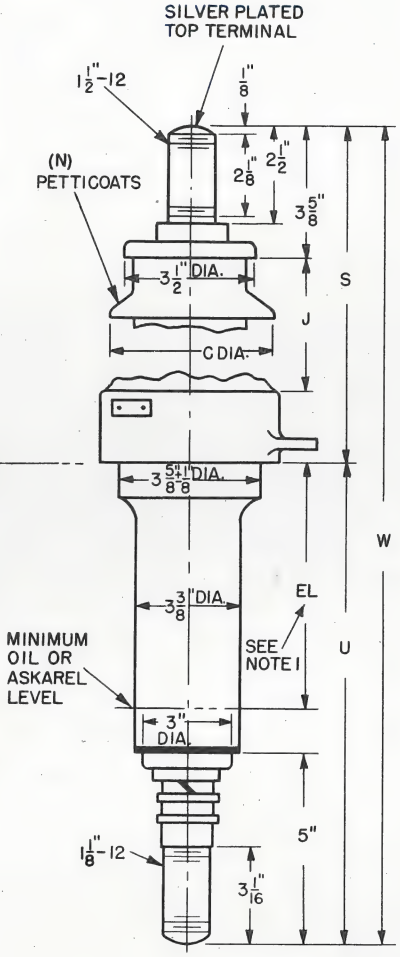
APPARATUS SUPERSEDED

SUPERSEDED TYPE A



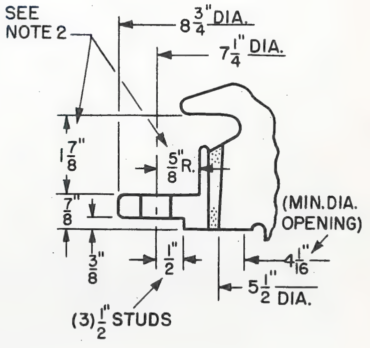
1"/8
TO CABLE
1 1/8"-12
1 3/4"
2 1/8"
3 1/16"
5 7/16"
(N) PETTI-COATS
4" DIA.
C DIA.
S
J
W
3 5/8"+1/8" DIA.
3 3/8" DIA.
EL
SEE NOTE 1
U
MINIMUM OIL OR ASKAREL LEVEL
1 9/16" DIA. HOLE

FIG. 1



SILVER PLATED TOP TERMINAL
1 1/2"-12
1"/8
(N) PETTICOATS
2 1/8"
2 1/2"
3 5/8"
3 1/2" DIA.
S
J
C DIA.
W
3 5/8"+1/8" DIA.
3 3/8" DIA.
EL
SEE NOTE 1
U
MINIMUM OIL OR ASKAREL LEVEL
3" DIA.
5"
1 1/8"-12
3 1/16"

FIG. 2



SEE NOTE 2
8 3/4" DIA.
7 1/4" DIA.
1 7/8"
5/8" R.
7/8"
3/8"
1/2"
(MIN. DIA. OPENING)
4 1/16"
5 1/2" DIA.
(3) 1/2" STUDS

Note 1—EL designates exposable length of porcelain required for proper oil or askarel immersion level.

Note 2—Space too restricted for use of ordinary socket wrench.

Note 3—The mounting flange and gasket on the cover of the apparatus in which these bushings are installed should be so designed as to prevent contact between the porcelain of the bushing and the metal flange on the cover of the apparatus.

Class	Amperes	Catalog Number	Fig. No.	N	Dimensions— Inches						Net Wt. Pounds
					C	J	EL	S	U	W	
ADU 8.7A	400	81508	1	2	5 3/4	3 3/4	0	10 15/16	4 3/4	15 11/16	17
	400	81072	1	2	5 3/4	3 3/4	17 3/4	10 15/16	18 3/8	29 5/16	25
	1200	81077	2	2	5 3/4	3 3/4	0	9 1/8	11 15/16	21 1/16	17
	1200	81078	2	2	5 3/4	3 3/4	17 3/4	9 1/8	23 7/16	32 9/16	26
ADU 15A	400	81509	1	3	6 3/4	6 1/4	0	13 7/16	4 3/4	18 3/16	21
	400	81074	1	3	6 3/4	6 1/4	17 3/4	13 7/16	18 3/8	31 13/16	29
	1200	81083	2	3	6 3/4	6 1/4	0	11 5/8	11 15/16	23 9/16	20
	1200	81084	2	3	6 3/4	6 1/4	17 3/4	11 5/8	23 7/16	35 1/16	29

BUSHINGS
DESIGNS

TYPE LC
FORMER STANDARD FOR TRANSFORMERS

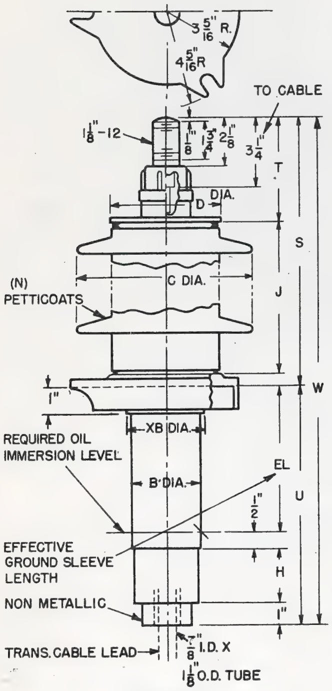

3 5/16" R.
4 5/16" R
1 1/8"-12
1/8"
1 3/4"
2 1/8"
TO CABLE
3 1/4"
T
D DIA.
S
(N) PETTICOATS
C DIA.
J
W
1"
XB DIA.
REQUIRED OIL IMMERSION LEVEL
B DIA.
EL
1/2"
U
EFFECTIVE GROUND SLEEVE LENGTH
H
NON METALLIC
1"
TRANS. CABLE LEAD
7/8" I.D. X
1 1/8" O.D. TUBE

FIGURE 1

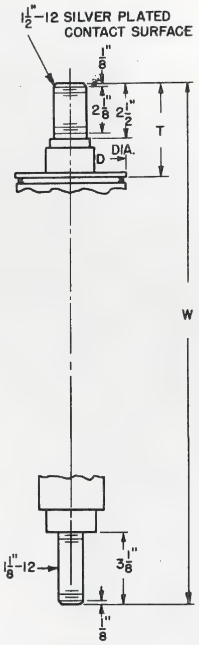

1 1/2"-12 SILVER PLATED CONTACT SURFACE
1/8"
2 1/8"
2 1/2"
T
D DIA.
W
1 1/8"-12
3 1/8"
1/8"

FIGURE 2
OTHERWISE SAME AS FIGS.1&3

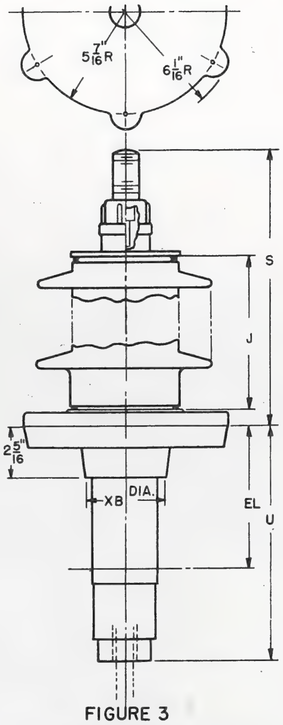
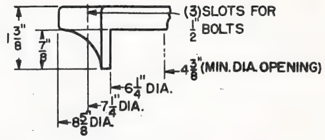
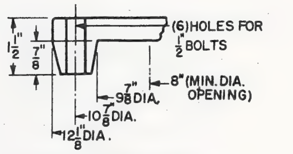

5 7/16" R
6 1/16" R
S
J
2 5/16"
XB DIA.
EL
U

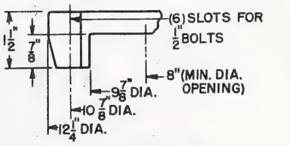
FIGURE 3
OTHERWISE SAME AS FIG.1


(3) SLOTS FOR 1/2" BOLTS
1 3/8"
7/8"
4 3/8" (MIN. DIA. OPENING)
6 1/4" DIA.
7 1/4" DIA.
8 5/8" DIA.

FLANGE DETAIL FIG.4


(6) HOLES FOR 1/2" BOLTS
1 1/2"
7/8"
8" (MIN. DIA. OPENING)
9 7/8" DIA.
10 7/8" DIA.
12 1/8" DIA.

FLANGE DETAIL FIG.5

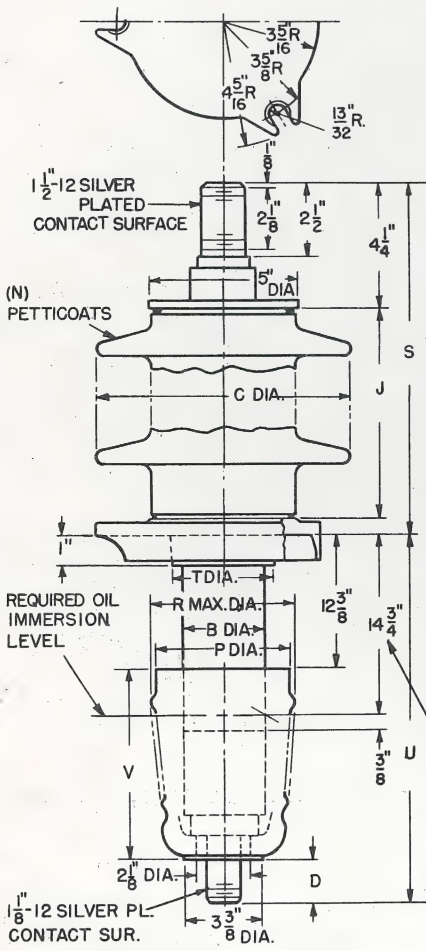

(6) SLOTS FOR 1/2" BOLTS
1 1/2"
7/8"
8" (MIN. DIA. OPENING)
9 7/8" DIA.
10 7/8" DIA.
12 1/4" DIA.

FLANGE DETAIL FIG.6

Class	Ampere	Catalog Number	Fig. No.	Flange Fig. No.	N	Dimensions—Inches											Approx. Net Wt. Filled in Lbs.
						B	C	D	H	J	EL	S	T	U	W	XB	
A15A	400	83001	1	4	3	2 3/8	7 1/4	3 3/4	3	6 3/16	11 3/4	11 7/16	6	16 1/4	29	2 3/4	18
	400	83006	1	4	3	2 3/8	7 1/4	3 3/4	3	6 3/16	20 3/4	11 7/16	6	25 1/4	38	2 3/4	20
	1200	83010	2	4	3	2 3/8	7 1/4	3 3/4	3	6 1/4	11 3/4	10 15/16	4 1/8	19 3/8	30 5/16	2 3/4	26
	1200	83050	2	4	3	2 3/8	7 1/4	3 3/4	3	6 1/4	20 3/4	10 15/16	4 1/8	28 3/8	39 5/16	2 3/4	30
A25A	400	83002	1	4	4	2 3/4	8 1/2	5	5	9 1/4	11 3/4	14 7/8	5 1/16	18 1/4	33 1/8	3 1/8	32
	400	83006	1	4	4	2 3/4	8 1/2	5	5	9 1/4	20 3/4	14 7/8	5 1/16	27 1/4	42 1/8	3 1/8	35
	1200	83020	2	4	4	2 3/4	8 1/2	5	5	9 1/4	11 3/4	14 1/16	4 3/16	21 3/8	35 3/8	3 1/8	42
	1200	83060	2	4	4	2 3/4	8 1/2	5	5	9 1/4	20 3/4	14 1/16	4 3/16	30 3/8	44 3/8	3 1/8	47
A34.5	400	83003	1	4	4	3 1/8	8 1/2	5	7	11 3/8	11 3/4	17	5 1/16	20 1/4	37 1/4	3 9/16	36
	400	83007	1	4	4	3 1/8	8 1/2	5	7	11 3/8	20 3/4	17	5 1/16	29 1/4	46 1/4	3 9/16	41
	1200	83030	2	4	4	3 1/8	8 1/2	5	7	11 3/8	11 3/4	16 3/16	4 3/16	23 3/8	39 1/2	3 9/16	46
	1200	83070	2	4	4	3 1/8	8 1/2	5	7	11 3/8	26 3/4	16 3/16	4 3/16	38 3/8	54 1/2	3 9/16	56
A46	400	83004	3	5	5	3 1/8	9 3/8	5	9	13 7/8	11 3/4	19 5/8	4 3/4	22 1/4	41 7/8	4 1/2	69
	400	83008	3	5	5	3 1/8	9 3/8	5	9	13 7/8	20 3/4	19 5/8	4 3/4	31 1/4	50 7/8	4 1/2	72
	1200	83040	2	5	5	3 1/8	9 3/8	5	9	13 7/8	11 3/4	18 3/4	4 1/4	25 3/8	44 1/8	4 1/2	65
	1200	83080	2	5	5	3 1/8	9 3/8	5	9	13 7/8	26 3/4	18 3/4	4 1/4	40 3/8	59 1/8	4 1/2	75
A69	400	83091	3	6	7	4 3/8	11 5/16	5	13 1/2	22 1/4	11 3/4	28 1/16	5 1/8	26 3/4	54 13/16	5	94
	400	83009	3	6	7	4 3/8	11 5/16	5	13 1/2	22 1/4	20 3/4	28 1/16	5 1/8	35 3/4	63 13/16	5	100

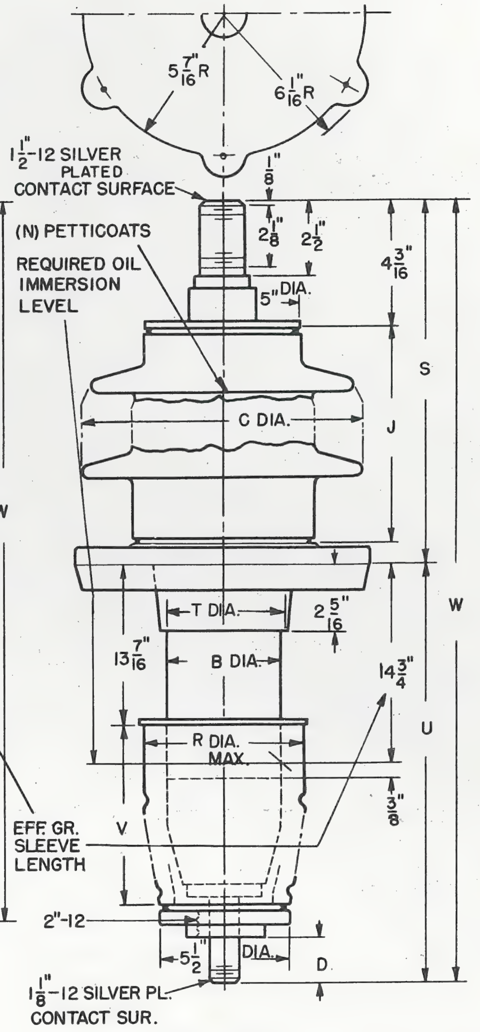
APPARATUS SUPERSEDED

TYPE LC
FORMER STANDARD FOR CIRCUIT BREAKERS



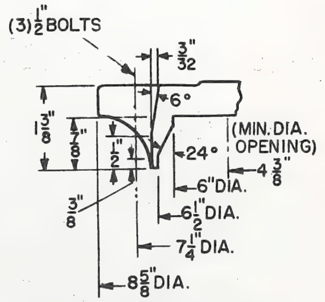
3 5/16" R
3 5/8" R
4 5/16" R
13/32" R.
1/8"
1 1/2"-12 SILVER PLATED CONTACT SURFACE
2 1/8"
2 1/2"
4 1/4"
5" DIA.
(N) PETTICOATS
C DIA.
S
J
W
1"
T DIA.
R MAX. DIA.
B DIA.
P DIA.
REQUIRED OIL IMMERSION LEVEL
12 3/8"
14 3/4"
3/8"
U
V
2 1/8" DIA.
D
1 1/8"-12 SILVER PL. CONTACT SUR.
3 3/8" DIA.

FIGURE I



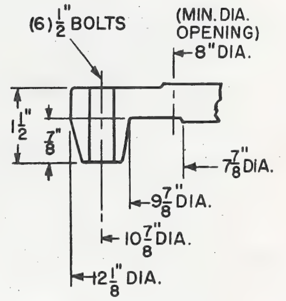
5 7/16" R
6 1/16" R
1 1/2"-12 SILVER PLATED CONTACT SURFACE
1/8"
(N) PETTICOATS
REQUIRED OIL IMMERSION LEVEL
2 1/8"
2 1/2"
4 3/16"
5" DIA.
S
C DIA.
J
W
T DIA.
2 5/16"
13 7/16"
B DIA.
14 3/4"
U
R DIA. MAX.
3/8"
EFF. GR. SLEEVE LENGTH
V
2"-12
5 1/2" DIA.
D
1 1/8"-12 SILVER PL. CONTACT SUR.

FIGURE 2



(3) 1/2" BOLTS
3/32"
6°
1 3/8"
7/8"
1/2"
24°
(MIN. DIA. OPENING)
4 3/8"
6" DIA.
6 1/2" DIA.
7 1/4" DIA.
3/8"
8 5/8" DIA.

FLANGE DETAIL FOR FIG. I



(6) 1/2" BOLTS
(MIN. DIA. OPENING)
8" DIA.
1 1/2"
7/8"
7 7/8" DIA.
9 7/8" DIA.
10 7/8" DIA.
12 1/8" DIA.

FLANGE DETAIL FOR FIG. 2

Class	Ampere	Catalog Number	Fig. No.	N	Dimensions — in Inches											Approx. Net Wt. Filled in Lbs.	Less Bottom Porc.
					B	C	D	J	P	R	S	T	U	V	W		
BA25A	600	85813	1	4	2¾	8½	1¾	9¼	5⅛	5⅝	14⅟16	4¼	24⅜	10¼	38⁷⁄16	60	83105
	1200	85914	1	4	2¾	8½	1¾	9¼	5⅛	5⅝	14⅟16	4¼	24⅜	10¼	38⁷⁄16	60	
BA37A	600	85814	1	5	3⅛	9⅜	1¾	13⅞	5⅝	6⅛	18¹¹⁄16	4¼	26⅜	12¼	45⅟16	75	83106
	1200	85915	1	5	3⅛	9⅜	1¾	13⅞	5⅝	6⅛	18¹¹⁄16	4¼	26⅜	12¼	45⅟16	75	
BA50A	600	85815	2	8	3¾	9½	1¹¹⁄16	18¾	—	6¹⁵⁄16	23¹¹⁄16	4¼	27⅞	12	51½	125	83107
	1200	85916	2	8	3¾	9½	2³⁄16	18¾	—	6¹⁵⁄16	23¹¹⁄16	4¼	28⅜	12	52	125	

BUSHINGS
DESIGNS

SUPERSEDED
TYPE L
FOR TRANSFORMERS

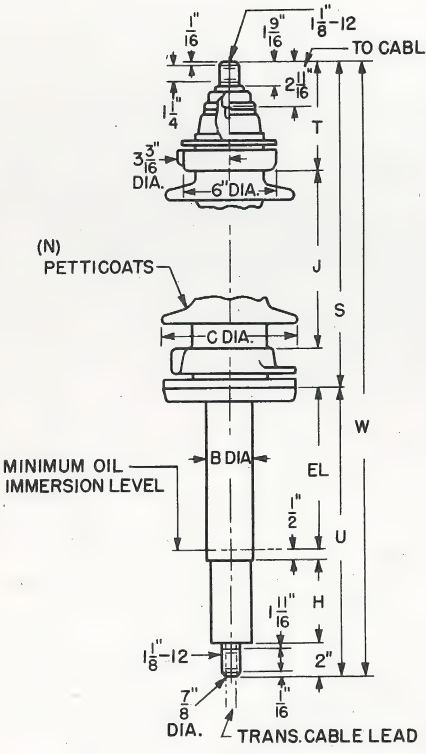

1"/16
1 9"/16
1 1"/8-12
TO CABLE
2 11"/16
1 1"/4
T
3 3"/16 DIA.
6" DIA.
(N) PETTICOATS
J
S
C DIA.
W
MINIMUM OIL IMMERSION LEVEL
B DIA.
EL
1"/2
U
H
1 11"/16
1 1"/8-12
2"
7"/8 DIA.
1"/16
TRANS. CABLE LEAD

FIG. 1

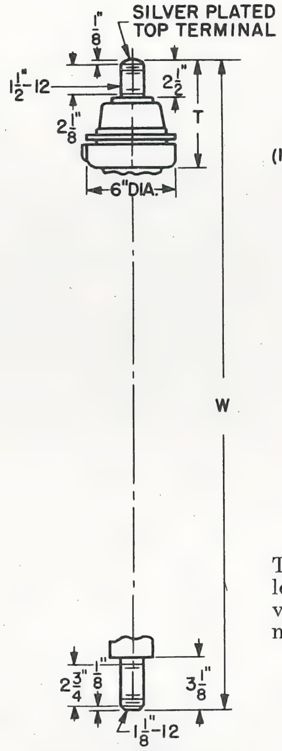

1"/8
SILVER PLATED TOP TERMINAL
1 1"/2-12
2 1"/2
T
2 1"/8
6" DIA.
W
2 3"/4
1"/8
3 1"/8
1 1"/8-12

FIG. 2
OTHERWISE SAME AS FIG. 1

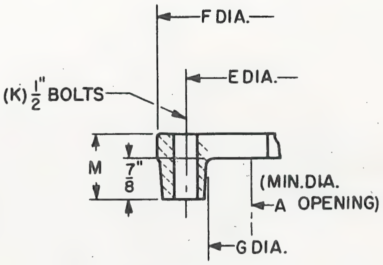

F DIA.
E DIA.
(K) 1"/2 BOLTS
M
7"/8
(MIN. DIA.
A OPENING)
G DIA.

FIG. 3
FLANGE DETAIL FOR FIGS. 1 & 2

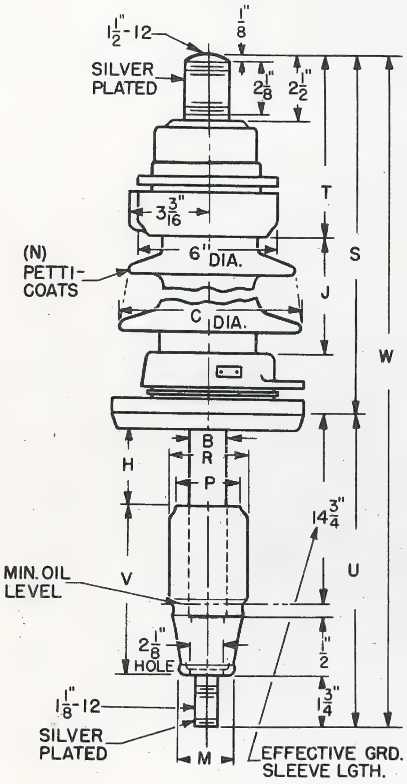
The effective ground sleeve length and length of bushing below flange can be varied within limits to suit apparatus made by different manufacturers.

Class	Ampere	Catalog Number	Fig. No.	N	Dimensions — Inches															Approx. Net Wt. Filled Lbs.
					A	B	C	E	F	G	H	J	K	M	EL	S	T	U	W	
A25A	400	83421	1	4	4 3/8	2 3/4	8 5/8	7 1/4	8 1/2	6 1/4	6	8 1/4	3	1 3/8	11 3/4	17 11/16	6 15/16	20 1/4	37 15/16	45
	400	83626	1	4	4 3/8	2 3/4	8 5/8	7 1/4	8 1/2	6 1/4	6	8 1/4	3	1 3/8	20 3/4	17 11/16	6 15/16	29 1/4	46 15/16	52
	1200	83432	2	4	4 3/8	2 3/4	8 5/8	7 1/4	8 1/2	6 1/4	6	8 1/4	3	1 3/8	11 3/4	17 3/8	6 5/8	21 3/8	38 3/4	52
	1200	83632	2	4	4 3/8	2 3/4	8 5/8	7 1/4	8 1/2	6 1/4	6	8 1/4	3	1 3/8	20 3/4	17 3/8	6 5/8	30 3/8	47 3/4	63
A34.5	400	83441	1	4	4 3/8	3 1/8	8 7/8	7 1/4	8 1/2	6 1/4	8	10 1/2	3	1 3/8	11 3/4	19 15/16	6 15/16	22 1/4	42 3/16	53
	400	83641	1	4	4 3/8	3 1/8	8 7/8	7 1/4	8 1/2	6 1/4	8	10 1/2	3	1 3/8	20 3/4	19 15/16	6 15/16	31 1/4	51 3/16	64
	1200	83452	2	4	4 3/8	3 1/8	8 7/8	7 1/4	8 1/2	6 1/4	8	10 1/2	3	1 3/8	11 3/4	19 5/8	6 5/8	23 3/8	43	60
	1200	83652	2	4	4 3/8	3 1/8	8 7/8	7 1/4	8 1/2	6 1/4	8	10 1/2	3	1 3/8	26 3/4	19 5/8	6 5/8	38 3/8	58	73
A46	400	83481	1	5	8	3 3/4	10 5/8	10 7/8	12 1/8	9 7/8	10	14	6	1 1/2	11 3/4	23 5/8	6 15/16	24 1/4	47 7/8	88
	400	83661	1	5	8	3 3/4	10 5/8	10 7/8	12 1/8	9 7/8	10	14	6	1 1/2	20 3/4	23 5/8	6 15/16	33 1/4	56 7/8	102
	1200	83492	2	5	8	3 3/4	10 5/8	10 7/8	12 1/8	9 7/8	10	14	6	1 1/2	11 3/4	23 1/4	6 5/8	25 3/8	48 5/8	97
	1200	83672	2	5	8	3 3/4	10 5/8	10 7/8	12 1/8	9 7/8	10	14	6	1 1/2	26 3/4	23 1/4	6 5/8	40 3/8	63 5/8	118
A69	400	83521	1	7	8	4 7/8	12	10 7/8	12 1/8	9 7/8	14	22 1/8	6	1 1/2	11 3/4	31 3/4	6 15/16	28 1/4	60	140
	400	83681	1	7	8	4 7/8	12	10 7/8	12 1/8	9 7/8	14	22 1/8	6	1 1/2	20 3/4	31 11/16	6 15/16	37 1/4	68 15/16	170
	1200	83532	2	7	8	4 7/8	12	10 7/8	12 1/8	9 7/8	14	22 1/8	6	1 1/2	11 3/4	31 7/16	6 5/8	29 3/8	60 13/16	148
	1200	83696	2	7	8	4 7/8	12	10 7/8	12 1/8	9 7/8	14	22 1/8	6	1 1/2	26 3/4	31 7/16	6 5/8	44 3/8	75 13/16	180

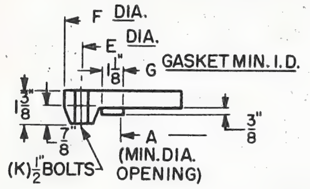
APPARATUS SUPERSEDED

SUPERSEDED TYPE L FOR CIRCUIT BREAKERS

FIG.1



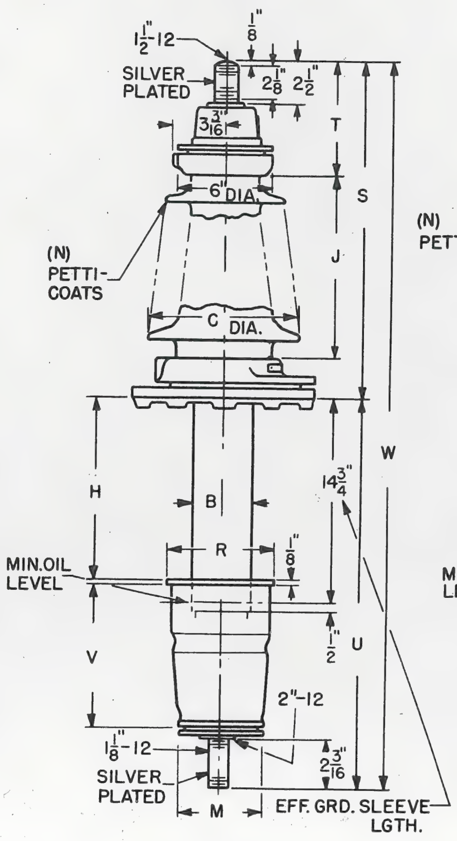
1½"-12
1/8"
SILVER PLATED
2⅛"
2½"
3 3/16"
T
S
W
(N) PETTI-COATS
6" DIA.
J
C DIA.
H
B
R
P
14¾"
MIN. OIL LEVEL
V
U
2⅛" HOLE
½"
1¾"
1⅛"-12
SILVER PLATED
M
EFFECTIVE GRD. SLEEVE LGTH.



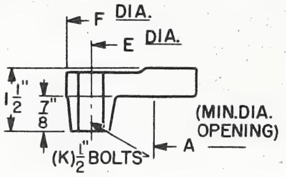
F DIA.
E DIA.
1⅛"
G GASKET MIN. I.D.
1⅜"
7/8"
3/8"
A
(K)½" BOLTS
(MIN. DIA. OPENING)

FLANGE DETAIL

FIG.2



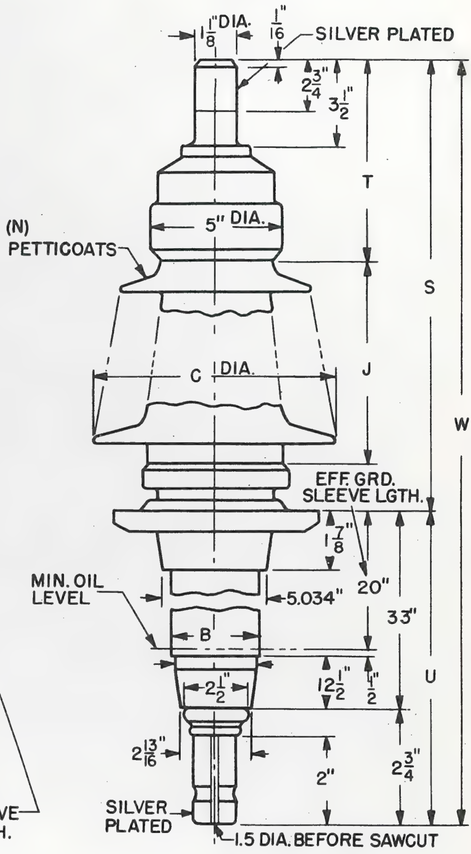
1½"-12
1/8"
SILVER PLATED
2⅛"
2½"
3 3/16"
T
S
6" DIA.
(N) PETTI-COATS
J
C DIA.
W
H
B
14¾"
R
1/8"
MIN. OIL LEVEL
½"
U
V
2"-12
1⅛"-12
2 3/16"
SILVER PLATED
M
EFF. GRD. SLEEVE LGTH.



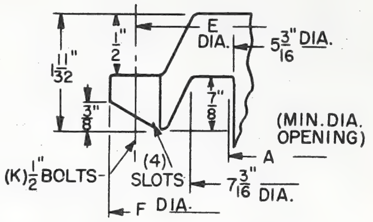
F DIA.
E DIA.
1½"
7/8"
(MIN. DIA. OPENING)
A
(K)½" BOLTS

FLANGE DETAIL

FIG.3



1⅛" DIA.
1/16"
SILVER PLATED
2¾"
3½"
T
5" DIA.
(N) PETTICOATS
S
W
C DIA.
J
EFF. GRD. SLEEVE LGTH.
1⅞"
20"
33"
MIN. OIL LEVEL
5.034"
B
2½"
12½"
½"
U
2 13/16"
2"
2¾"
SILVER PLATED
1.5 DIA. BEFORE SAWCUT



1 11/32"
½"
E DIA.
5 3/16" DIA.
3/8"
7/8"
(MIN. DIA. OPENING)
A
(K)½" BOLTS
(4) SLOTS
7 3/16" DIA.
F DIA.

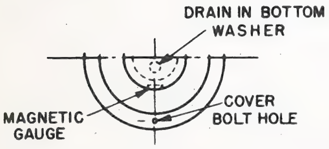
FLANGE DETAIL

Class	Ampere	Catalog Number	Fig. No.	N	Dimensions — Inches																	Approx. Net Wt. Filled Lbs.
					A	B	C	E	F	G	H	J	K	M	P	R	S	T	U	V	W	
BA25A	1200	83786	1	4	4⅜	2¾	8⅝	7¼	8½	4	12⅜	8¼	3	5¼	5⅛	5½	17⅜	6⅝	24⅜	10¼	41¾	103
BA37A	1200	83791	1	5	4⅜	3⅛	9½	7¼	8½	4	12⅜	13	3	5¾	5⅝	6	22⅛	6⅝	26⅜	12¼	48½	122
BA50A	1200	83795	2	6	8	3¾	10⅞	10⅞	12⅛	..	13 5/16	18⅛	6	5½	...	6¾	27 7/16	6⅝	28⅜	12	55 13/16	140
BK73A*	1200	83741	3	9	5½	4⅞	11½	9¾	10¾	..	....	28	4	4¾	...	...	37⅞	7 13/16	35¾	....	73⅝	160

* Solder Seal Assembly.

BUSHINGS DESIGNS

SUPERSEDED
TYPE F
FOR TRANSFORMERS


DRAIN IN BOTTOM WASHER
MAGNETIC GAUGE
COVER BOLT HOLE

ALIGNMENT VIEW FROM TOP

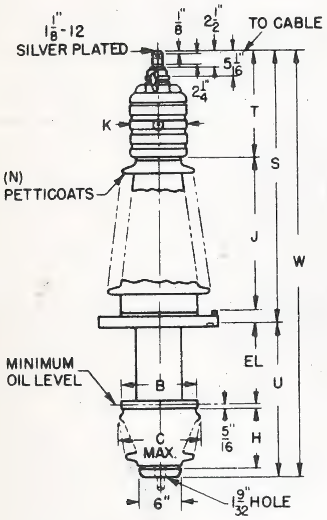
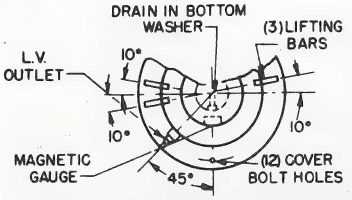

1 1/8"-12 SILVER PLATED
1/8"
2 1/2"
TO CABLE
5 1/16"
2 1/4"
K
T
S
(N) PETTICOATS
J
W
EL
U
MINIMUM OIL LEVEL
B
C MAX.
5/16"
H
6"
1 9/32" HOLE

FIG. 1


DRAIN IN BOTTOM WASHER
(3) LIFTING BARS
L.V. OUTLET
10°
10°
10°
10°
MAGNETIC GAUGE
45°
(12) COVER BOLT HOLES

ALIGNMENT VIEW FROM TOP

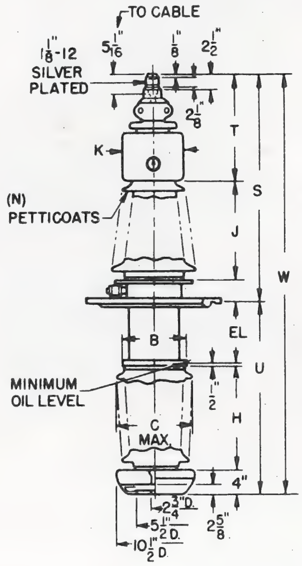
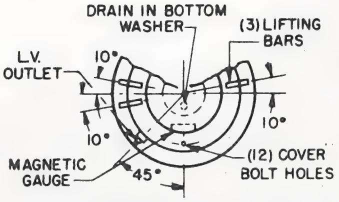

TO CABLE
1 1/8"-12 SILVER PLATED
5 1/16"
1/8"
2 1/2"
2 1/8"
K
T
S
(N) PETTICOATS
J
W
EL
B
U
MINIMUM OIL LEVEL
1/2"
H
C MAX.
4"
2 3/4" D.
5 1/2" D.
10 1/2" D.
2 5/8"

FIG.2


DRAIN IN BOTTOM WASHER
(3) LIFTING BARS
L.V. OUTLET
10°
10°
10°
MAGNETIC GAUGE
45°
(12) COVER BOLT HOLES

ALIGNMENT VIEW FROM TOP

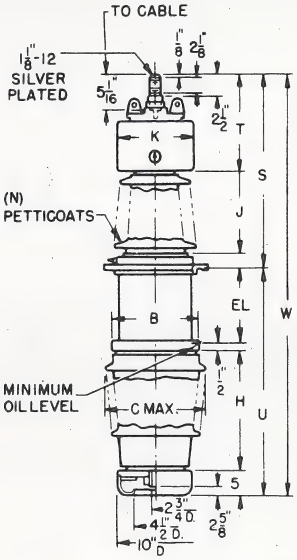
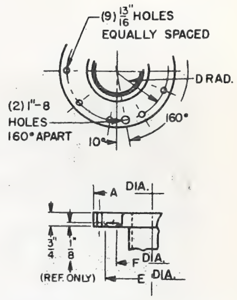
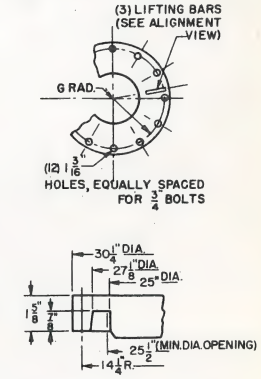

TO CABLE
1 1/8"-12 SILVER PLATED
5 1/16"
1/8"
2 1/8"
2 1/2"
K
T
S
(N) PETTICOATS
J
W
EL
B
U
MINIMUM OIL LEVEL
C MAX.
1/2"
H
5
2 3/4" D.
4 1/2" D.
10" D
2 5/8"

FIG.3


(9) 13/16" HOLES EQUALLY SPACED
D RAD.
(2) 1"-8 HOLES 160° APART
160°
10°
A DIA.
3/4"
1/8"
F DIA.
(REF. ONLY)
E DIA.

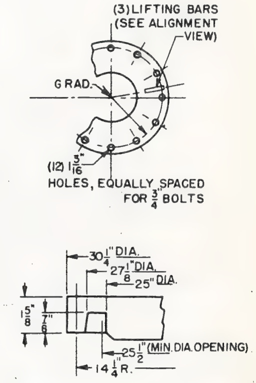
MOUNTING FLANGE DETAILS

FIG. 1


(3) LIFTING BARS (SEE ALIGNMENT VIEW)
G RAD.
(12) 1 3/16" HOLES, EQUALLY SPACED FOR 3/4" BOLTS
30 1/4" DIA.
27 1/8" DIA.
25" DIA.
1 5/8"
7/8"
25 1/2" (MIN. DIA. OPENING)
14 1/4" R.

MOUNTING FLANGE DETAILS

FIG.2


(3) LIFTING BARS (SEE ALIGNMENT VIEW)
G RAD.
(12) 1 3/16" HOLES, EQUALLY SPACED FOR 3/4" BOLTS
30 1/4" DIA.
27 1/8" DIA.
25" DIA.
1 5/8"
7/8"
25 1/2" (MIN. DIA. OPENING)
14 1/4" R.

MOUNTING FLANGE DETAILS

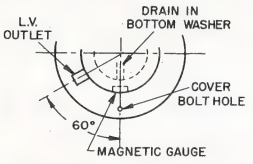
FIG.3

Class	Amp.	Catalog Number	Fig. No.	N	Dimensions—Inches														Approx. Net Wt. Filled, Lbs.	Approx. Capac. Gallons
					A	B	C	D	E	F	H	J	K	EL	S	T	U	W		
A115*	800	86614	1	11	21	10½	10⅞	9⁷⁄₁₆	17½	15⅜	17½	34⅛	10¾	13¾	56	20⁷⁄₁₆	32⁵⁄₁₆	88⁵⁄₁₆	510	6¾
A115*	800	86624	1	11	21	10½	10⅞	9⁷⁄₁₆	17½	15⅜	17½	34⅛	10¾	26¾	56	20⁷⁄₁₆	45⁵⁄₁₆	101⁵⁄₁₆	540	8
A138	800	86616	1	12	22⅞	12⅝	12⅞	10⅜	19⅜	17¼	21¼	40⅛	11¾	13¾	64¹⁵⁄₁₆	23⅜	36¹⁄₁₆	101	620	14
A138	800	86626	1	12	22⅞	12⅝	12⅞	10⅜	19⅜	17¼	21¼	40⅛	11¾	26¾	64¹⁵⁄₁₆	23⅜	49¹⁄₁₆	114	710	16½
A161	800	86618	1	13	25	14⅝	14⅞	11⁷⁄₁₆	21½	19⅜	24¾	47⁷⁄₁₆	12¼	13¾	73¾	25¹¹⁄₁₆	39⁹⁄₁₆	113⁵⁄₁₆	905	21
A161	800	86628	1	13	25	14⅝	14⅞	11⁷⁄₁₆	21½	19⅜	24¾	47⁷⁄₁₆	12¼	26¾	73¾	25¹¹⁄₁₆	52⁹⁄₁₆	126⁵⁄₁₆	990	25
AJ196	800	86661	2	17	—	17½	18⁵⁄₁₆	—	—	—	32⅜	64¹¹⁄₁₆	15½	33⅛	111	40¹¹⁄₁₆	70	181	3000	55
AJ230	800	86662	3	19	30¼	19⅝	19⅞	14¼	27¼	35	37	74¹¹⁄₁₆	18	31³⁄₁₆	111¾	31⁹⁄₁₆	72¹¹⁄₁₆	184⁷⁄₁₆	3700	72

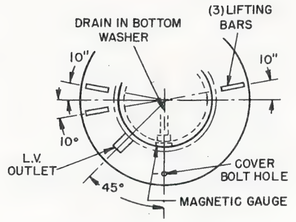
* 400 ampere ratings can be supplied if specified.

APPARATUS
SUPERSEDED DESIGN

SUPERSEDED
TYPE F
FOR CIRCUIT BREAKERS


L.V. OUTLET
DRAIN IN BOTTOM WASHER
COVER BOLT HOLE
60°
MAGNETIC GAUGE

ALIGNMENT VIEW FROM TOP


DRAIN IN BOTTOM WASHER
(3) LIFTING BARS
10"
10"
10°
L.V. OUTLET
45°
COVER BOLT HOLE
MAGNETIC GAUGE

ALIGNMENT VIEW FROM TOP

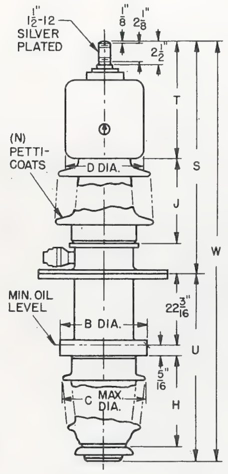
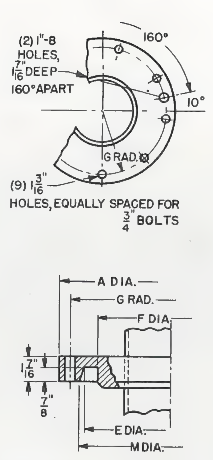

$1\frac{1}{2}$"-12 SILVER PLATED
$\frac{1}{8}$"
$2\frac{1}{8}$"
$2\frac{1}{2}$"
T
S
W
(N) PETTI-COATS
D DIA.
J
MIN. OIL LEVEL
$22\frac{3}{16}$"
B DIA.
U
$\frac{5}{16}$"
C MAX. DIA.
H

FIG.1


(2) 1"-8 HOLES, $1\frac{7}{16}$" DEEP 160° APART
160°
10°
G RAD.
(9) $1\frac{3}{16}$" HOLES, EQUALLY SPACED FOR $\frac{3}{4}$" BOLTS
A DIA.
G RAD.
F DIA.
$1\frac{7}{16}$"
$\frac{7}{8}$"
E DIA.
M DIA.

MOUNTING FLANGE DETAILS

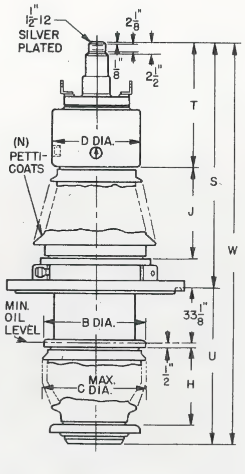
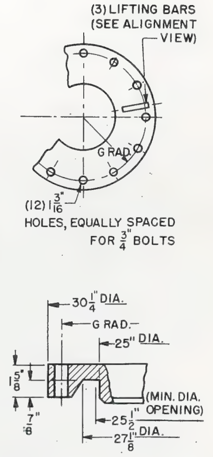
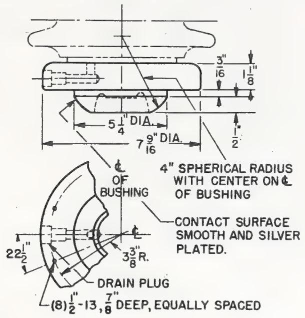

$1\frac{1}{2}$"-12 SILVER PLATED
$2\frac{1}{8}$"
$\frac{1}{8}$"
$2\frac{1}{2}$"
T
S
W
D DIA.
(N) PETTI-COATS
J
MIN. OIL LEVEL
$33\frac{1}{8}$"
B DIA.
U
$\frac{1}{2}$"
C MAX. DIA.
H

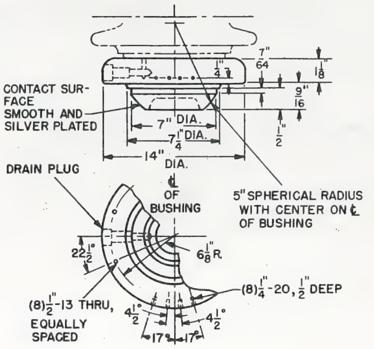
FIG.2


(3) LIFTING BARS (SEE ALIGNMENT VIEW)
G RAD.
(12) $1\frac{3}{16}$" HOLES, EQUALLY SPACED FOR $\frac{3}{4}$" BOLTS
$30\frac{1}{4}$" DIA.
G RAD.
25" DIA.
$1\frac{5}{8}$"
$\frac{7}{8}$"
(MIN. DIA. OPENING)
$25\frac{1}{2}$" DIA.
$27\frac{1}{8}$" DIA.

MOUNTING FLANGE DETAILS


$\frac{3}{16}$"
$1\frac{1}{8}$"
$5\frac{1}{4}$" DIA.
$7\frac{9}{16}$" DIA.
$\frac{1}{2}$"
℄ OF BUSHING
4" SPHERICAL RADIUS WITH CENTER ON ℄ OF BUSHING
CONTACT SURFACE SMOOTH AND SILVER PLATED.
℄
$22\frac{1}{2}$°
$3\frac{3}{8}$" R.
DRAIN PLUG
(8) $\frac{1}{2}$"-13, $\frac{7}{8}$" DEEP, EQUALLY SPACED

BOTTOM WASHER DETAILS


$\frac{7}{64}$"
$\frac{1}{4}$"
$1\frac{1}{8}$"
$\frac{9}{16}$"
CONTACT SURFACE SMOOTH AND SILVER PLATED
7" DIA.
$7\frac{1}{4}$" DIA.
$\frac{1}{2}$"
14" DIA.
DRAIN PLUG
℄ OF BUSHING
5" SPHERICAL RADIUS WITH CENTER ON ℄ OF BUSHING
$22\frac{1}{2}$°
$6\frac{1}{8}$" R.
(8) $\frac{1}{4}$"-20, $\frac{1}{2}$" DEEP
(8) $\frac{1}{2}$"-13 THRU, EQUALLY SPACED
$4\frac{1}{2}$°
$4\frac{1}{2}$°
17°
17°

BOTTOM WASHER DETAILS

Class	Amp.	Catalog Number	Fig. No.	N	Dimensions—Inches														Approx. Net Wt. Filled, Lbs.	Approx. Capac. Gallons
					A	B	C	D	E	F	G	H	J	M	S	T	U	W		
BJ115	1200	86605	1	11	21	10½	10⅞	10¾	17½	15⅜	9⅝	17½	34¹⁵⁄₁₆	17¹⁵⁄₁₆	57¹⁵⁄₁₆	18¹⁄₁₆	41⅝	99⁹⁄₁₆	595	8½
BJ138	1200	86606	1	12	22⅞	12⅝	12⅞	10¾	19⅜	17¼	10⁹⁄₁₆	21¼	40¹⁵⁄₁₆	19¹³⁄₁₆	66⅞	21	45⅜	112¼	790	16
BJ161	1200	86607	1	13	25	14⅝	14⅞	12¼	21½	19⅜	11⅝	24¾	47⁷⁄₁₆	21¹⁵⁄₁₆	75¹¹⁄₁₆	23⁵⁄₁₆	48⅞	124⁹⁄₁₆	1050	25
BJ196	1200	86608	2	17	—	17½	18⁵⁄₁₆	15½	—	—	14¼	32⅜	64¹¹⁄₁₆	—	111	40¹¹⁄₁₆	67¹¹⁄₁₆	178¹¹⁄₁₆	3000	55

BUSHINGS
TERMINAL CONNECTORS

Type A, LC, U and F Bushings with current ratings of 1200 amperes and below, include, at the top, one of two sizes of threaded terminal studs: 1⅛ inch for 400 amperes and below, and 1½ inch for 1200 amperes. For bushings between these ratings, the general practice is for those using detachable cable to have 1⅛ inch studs, while bushings with conductor tubes have 1½ inch terminal studs.

Both studs have 12 threads per inch. The use of only two sizes of terminal studs on Locke bushings not only permits a wide choice of connectors, but also reduces the number of connector designs required on a system.

The terminals shown are widely used. Additional sizes and designs are available upon request.

TOP TERMINAL CONNECTORS—BLADE TYPE

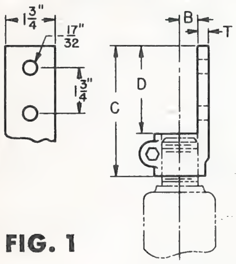


FIG. 1

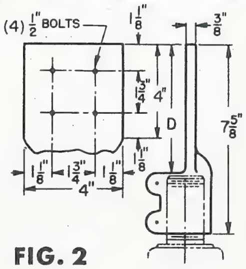


FIG. 2

Catalog Number		For Stud Size Inches	Fig. No.	Dimensions—Inches			
Plain	Silver Plated			C	D	B	T
84106	84157	¾-12	1	4⅝	3⅛	7/16	⅜
84102	84130	1⅛-12	1	4⅝	3⅛	⅝	5/16
84122	84133	1½-12	2	7⅝	5⅜	. .	⅜

TOP TERMINAL CONNECTORS—CLAMP TYPE

Accommodates one conductor vertically or two horizontally.

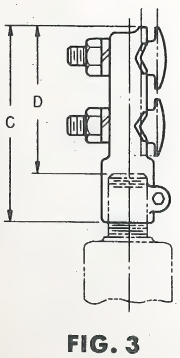
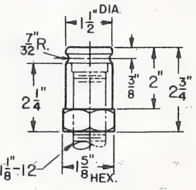


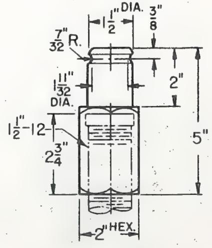
FIG. 3

Catalog Number		For Stud Size Inches	For Conductor Size Inches	Dimensions Inches—Fig. 3	
Plain	Silver Plated			C	D
84104	84126	¾-12	¼-1 1/16	5 5/16	4
84164	—	1 -12	¼-1 1/16	5 5/16	4
84103	84125	1⅛-12	¼-1 1/16	5 5/16	4
84172*	—	1⅛-12	¼-1 1/16	5 5/16	4

* Cadmium plated.



NO. 84014--400 AMP.



NO. 84016--1200 AMP.

APPARATUS
TERMINAL CONNECTORS

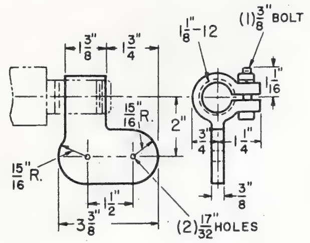

1 3/8"
1 3/4"
1 1/8"-12
(1) 3/8" BOLT
1/16"
15/16" R.
2"
3/4"
1 1/4"
15/16" R.
1 1/2"
3/8"
3 3/8"
(2) 17/32" HOLES

FIG. 1

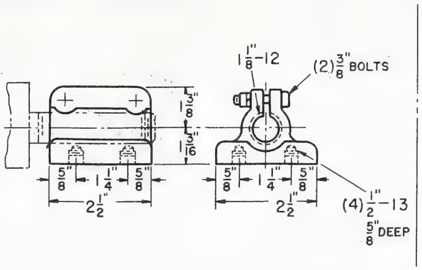

1 1/8"-12
(2) 3/8" BOLTS
1 3/8"
1 3/16"
5/8"
1 1/4"
5/8"
2 1/2"
5/8"
1 1/4"
5/8"
2 1/2"
(4) 1/2"-13
5/8" DEEP

FIG. 2

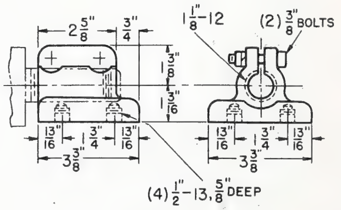

2 5/8"
3/4"
1 1/8"-12
(2) 3/8" BOLTS
1 3/8"
1 3/16"
13/16"
1 3/4"
13/16"
3 3/8"
13/16"
1 3/4"
13/16"
3 3/8"
(4) 1/2"-13, 5/8" DEEP

FIG. 3

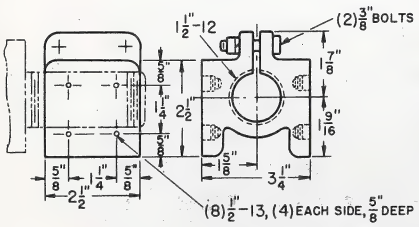

1 1/2"-12
(2) 3/8" BOLTS
5/8"
1 1/4"
5/8"
2 1/2"
1 7/8"
9/16"
5/8"
1 1/4"
5/8"
2 1/2"
1 5/8"
3 1/4"
(8) 1/2"-13, (4) EACH SIDE, 5/8" DEEP

FIG. 4

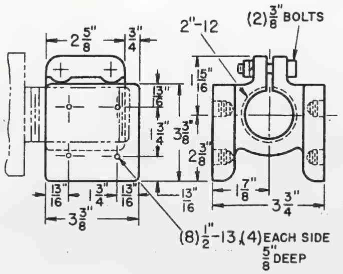

2 5/8"
3/4"
2"-12
(2) 3/8" BOLTS
1 15/16"
13/16"
1 3/4"
3 3/8"
2 3/8"
13/16"
1 3/4"
13/16"
3 3/8"
13/16"
1 7/8"
3 3/4"
(8) 1/2"-13, (4) EACH SIDE
5/8" DEEP

FIG. 5

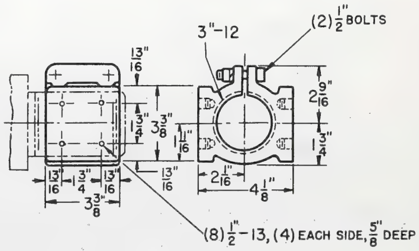
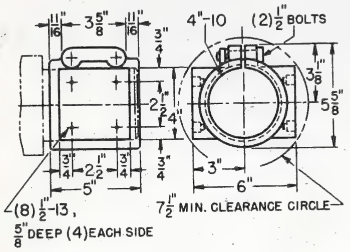
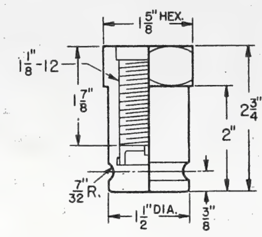

3"-12
(2) 1/2" BOLTS
13/16"
1 3/4"
3 3/8"
1 11/16"
2 9/16"
1 3/4"
13/16"
1 3/4"
13/16"
3 3/8"
13/16"
2 1/16"
4 1/8"
(8) 1/2"-13, (4) EACH SIDE, 5/8" DEEP

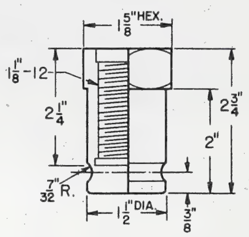
FIG. 6


11/16"
3 5/8"
11/16"
3/4"
4"-10
(2) 1/2" BOLTS
1"
3 3/8"
5 5/8"
2 1/2"
4"
3/4"
2 1/2"
3/4"
5"
3/4"
3"
6"
(8) 1/2"-13,
5/8" DEEP (4) EACH SIDE
7 1/2" MIN. CLEARANCE CIRCLE

4000 AMP.
CAT. NO. 84068 - PLAIN
CAT. NO. 84088 - SILVER PLATED


1 5/8" HEX.
1 1/8"-12
1 7/8"
2 3/4"
2"
7/32" R.
1 1/2" DIA.
3/8"

CAT. NO. 84015 400 AMP.

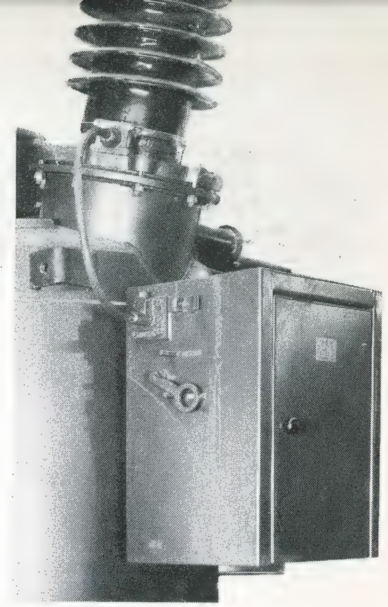

1 5/8" HEX.
1 1/8"-12
2 1/4"
2 3/4"
2"
7/32" R.
1 1/2" DIA.
3/8"

CAT. 84014 1200 AMP.

Catalog Number Plain	Catalog Number Silvered	Amp.	Fig. No.	Clearance Circles—Inches														
				Terminal (Eccentric of Bushing Axis)					Terminal & Ground Sleeve (Eccentric of Bushing Axis)					Terminal & Ground Sleeve (Concentric with Bushing Axis)				
				15 Kv	25 Kv	34.5 Kv	46 Kv	69 Kv	15 Kv	25 Kv	34.5 Kv	46 Kv	69 Kv	15 Kv	25 Kv	34.5 Kv	46 Kv	69 Kv
84061	84081	400	1	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 3/8	4 1/2	4 3/4	5	5 5/8	6 1/8	6 1/8	6 1/8	6 1/8	6 1/8
84062	84082	800	2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	4	5	3 3/4	3 3/4	3 3/4	4	5 1/8
84063	84083	1200	3	4	4	4	4	4	4	4	4	4 1/4	5 1/8	4 3/8	4 3/8	4 3/8	4 3/8	5 1/8
84064	84084	1600	4	4 1/2	4 1/2	4 1/2	4 1/2	...	4 1/2	4 1/2	4 1/2	4 5/8	...	4 3/4	4 3/4	4 3/4	4 3/4	...
84065	84085	2000	5	5 3/8	5 3/8	5 3/8	5 3/8	...	5 3/8	5 3/8	5 1/2	5 7/8	...	6 1/4	6 1/4	6 1/4	6 1/4	...
84066	84086	3000	6	5 5/8	5 5/8	5 5/8	...	...	5 5/8	5 5/8	5 5/8	...	...	5 3/4	5 3/4	5 3/4	...	...

BUSHINGS
POTENTIAL DEVICES

TYPE KA 106



The KA-106 bushing potential device is a reliable, safe and economical accessory for the operation of instruments and relays from high voltage circuits, 115 KV and up. It provides an inexpensive source of potential for most applications which do not require billing metering. The device utilizes the type U bushings for its capacitance coupling to the high-voltage line, and uses the bushing charging current as its source of energy. It supersedes the KA-105 device used with Type F bushings.

APPLICATION

The KA-106 bushing potential device is well suited to operate the usual types of relays, synchroscopes, voltmeters, indicating lamps, wattmeters (not for revenue) and similar instruments requiring a potential source of essentially constant ratio and phase relation with respect to the high-voltage circuit. Its major application is as part of protecting and control equipment for generating plants, substations, transmission lines, etc. It is not recommended where precise accuracy is required, and is not intended to take the place of high-voltage metering equipment.

The device is connected through the capacitance tap of the bushing (see page 180). The connection is made in the high-voltage circuit between one line and ground. Where three-phase connections are needed, three devices are used, one connected to each bushing of the three-phase circuit.

PERFORMANCE CHARACTERISTICS

The performance characteristics are well within the Class A limits established by AIEE Standard No. 31.

Potential devices contain both capacitance and inductance as essential elements in their resonant circuit network. Their circuit characteristics may be affected if burdens with comparatively large non-linear reactive components are used. Burdens including the use of closed iron magnetic circuits are to be avoided unless the iron-core magnetic material is operated at less than half the density required to reach the knee of its magnetization curve at normal voltage.

The majority of relays, synchroscopes, and meters have linear impedance within the usual range of variation in voltage. The device circuit is inherently stable throughout the operating range up to two times normal voltage when used with these usual types of burden. The protective gap is set to function at voltages over two times normal to protect the circuit from higher overvoltages.

RATING

The table below shows the watts output rating at 60 and 50 cycles for standard circuit voltage ratings from 115 through 330 KV. There are two separate secondary windings, each rated 115 volts, with a tap at 66.4 volts. All secondary voltages are normally in phase with the line-to ground voltage of the high-voltage system.

Bushing		Rated Circuit KV	Rated Line to Ground KV	Rated Watts Output	
Class KV	BIL KV			60 cy.	50 cy.
115	550	115	66.4	25	20
132	650	132	79.7	35	28
161	750	161	93.0	45	36
230	900	230	133.0	80	64
287.5	1050	287.5	166.0	Standard Ratings Not Established	
330	1175	330	190.0		

TYPE KA 106 (CONT.)

The rated burden is shown in the rating table. Greater volt-ampere burdens may be used if the watt component of the burden does not exceed the rated watt output of the device. In such a case the reactive component of the burden must be balanced by the addition of capacitance or inductance. The burden may be distributed between the two secondary windings to suit application requirements. The "main secondary terminals" should be used for the major burden, and the "auxiliary secondary terminals" should be used for the smaller burdens when required. In three-phase applications, these windings are often in "broken delta," when zero sequence voltage is required for ground-fault detection and relaying.

CONSTRUCTION

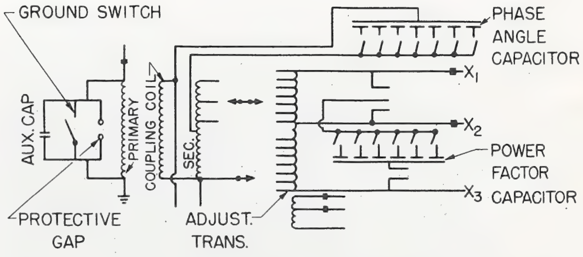
The device consists of a high reactance transformer, a ground switch, a protective gap, and the required adjustment equipment. An auxiliary capacitor is also provided, to supply the required value of capacitance from the high-voltage bushing capacitance tap to ground. These elements are in a weatherproof steel housing, provided with brackets for mounting on the side of the apparatus tank, indoors or outdoors.

The high reactance transformer unit is in an oil-filled sealed metal casing in the lower part of the housing. Porcelain bushings, mounted on the casing, bring out the high and low-voltage lead connections.

The grounding switch assembly is on the left side of the housing along with the protective gap assembly. The grounding switch is suitable for either switch-hook or hand operation. When the switch is closed, all voltage is removed from the device. The protective gap is adjusted inside the housing by means of a threaded stud and lock nut.

The adjusting equipment, consisting of an adjustment transformer, a phase-angle adjustment capacitor, and a power-factor-correction-capacitor, is mounted on the back of the terminal board where all the connections are made for adjusting the device. The transformer and the capacitors contain taps for adjustments. The terminal board, located just inside the housing door, is hinged to permit easy access to the switches and terminals used for making adjustments and connections (see photo on opposite page).

WIRING DIAGRAM



The auxiliary capacitor, which is supplied with this device, when requested, is in an oil filled, sealed metal case which is provided with a porcelain bushing through which the high-voltage lead is brought.

DIMENSIONS AND WEIGHT

The bushing potential device is 31 inches high over-all and has a projected floor space of 21 x 28 inches; it weighs approximately 400 pounds.

ORDERING INFORMATION

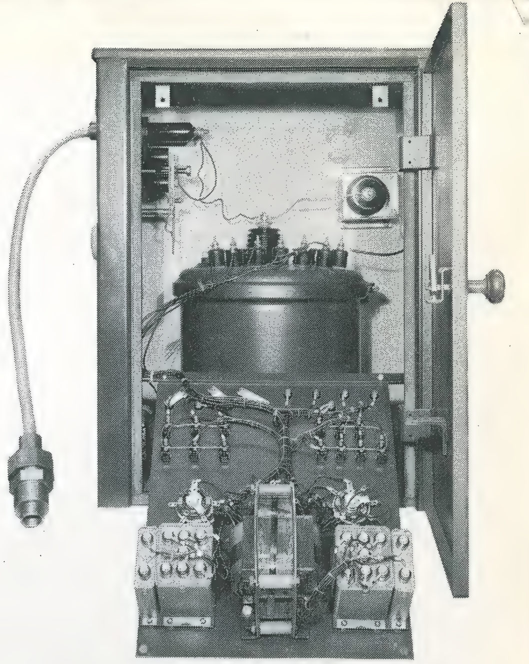
Please furnish the following information when ordering Type KA-106 potential measuring devices:

1. Catalog number of the bushing with which it is to be used.

2. Actual line-to-line voltage at which the bushing is to be operated. This is required, because some bushings are operated at voltages below their rating.

BUSHINGS
DEVICES

TYPE KA 106 (CONT.)



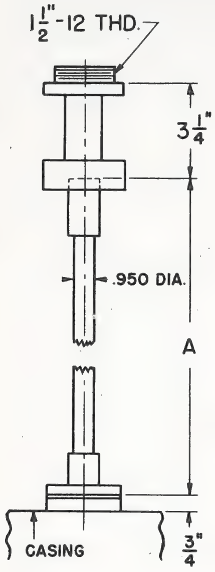
Adjustment panel tips forward to permit access to switches and terminals, used in making adjustments and connections.

3. Maximum required output of the device—in watts—if the required output is greater than listed in the table on page 193.

4. Length of leads from the potential measuring device to the relay, meter, or device to which it is to be connected. ("A" Dimension)

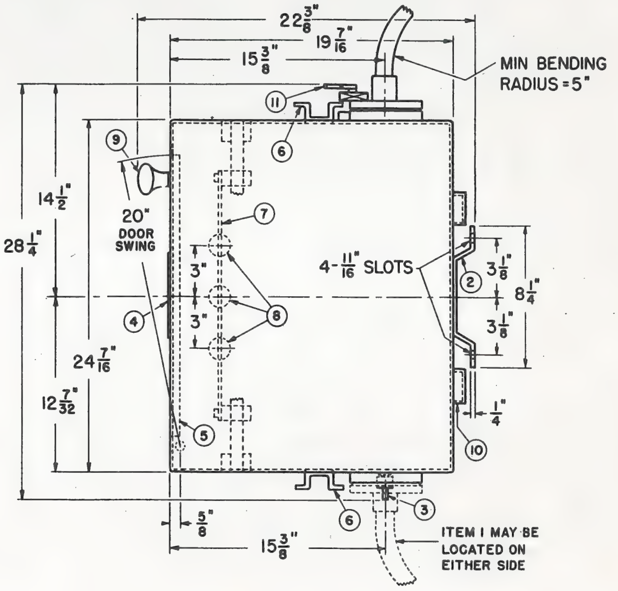
5. Frequency of circuit.

6. Secondary voltage required.

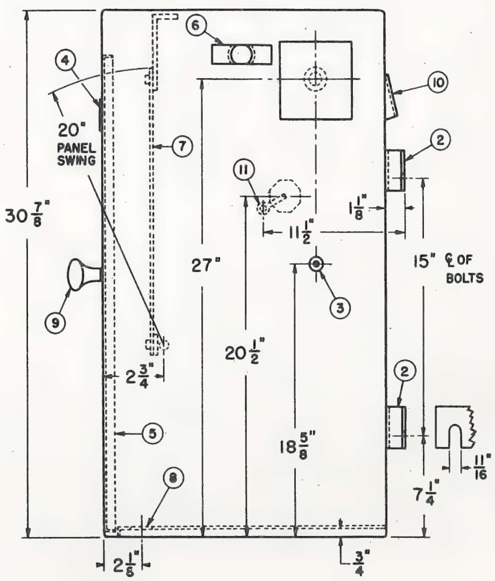


1½"-12 THD.
3¼"
.950 DIA.
A
CASING
¾"

DETAIL OF ITEM I



22⅜"
19 7/16"
15⅜"
MIN BENDING RADIUS = 5"
11
6
9
14½"
20" DOOR SWING
7
28¼"
3"
3"
4-11/16" SLOTS
2
3⅛"
8¼"
3⅛"
4
8
24 7/16"
12 7/32"
5
1/4"
10
6
3
5/8"
15⅜"
ITEM I MAY BE LOCATED ON EITHER SIDE



6
4
10
20" PANEL SWING
7
2
11
1⅛"
30⅞"
11½"
27"
15" ℄ OF BOLTS
3
9
20½"
2
2¾"
5
18⅝"
11/16"
8
7¼"
2⅛"
¾"

1. H. V. Cable Connection
2. Suspension Hook Bracket
3. Grd. Stud ⅜" - 16 NC-2 x ¾" long
4. Name Plate
5. Door Opening
6. Lifting Lug
7. Terminal Board
8. Knock Out for 1" IPS
9. Knob
10. Breather
11. Switch Lever

AMERICAN STANDARDS FOR APPARATUS

AIEE NO. 21
ASA C 76.1-1943

APPROVED AMERICAN STANDARDS ASSOCIATION JULY 23, 1943

SCOPE

21-1 These standards specifically cover the following types of bushings:

(a) Outdoor bushings for large apparatus.

(b) Cover type bushings for small apparatus.

(c) Indoor bushings for all types of apparatus except dry type instrument transformers, air-blast transformers, dry type regulators, and circuit breakers rated below 5,000 volts, and non-oiltight oil circuit breakers rated 50,000 kva or less.

These standards are not intended to apply to wall bushings, cable potheads, nor insulators for back-connected disconnecting switches, although many of the principles may be applicable.

The bushing requirements as specified in these standards apply to bushings when mounted for testing in accordance with specified arrangements as given in the Test Code (**Appendix I**). Requirements when installed in apparatus should be covered by standards for such apparatus.

SERVICE CONDITIONS

21-5 **Usual Service Conditions.** Apparatus bushings conforming to these standards shall be suitable for operation at their standard ratings:

(a) When and where the temperature of the external cooling medium does not exceed 40C maximum.

(b) Where the altitude does not exceed 3300 feet (1000 meters).

21-6 **Unusual Service Conditions.** The use of apparatus in external cooling media having temperatures higher than 40C maximum, or at altitudes greater than 3300 feet (1000 meters) should be considered as special.

Temperature Rise: For apparatus intended for service at altitudes greater than 3300 feet (1000 meters) it is provisionally agreed that the permissible temperature rises (as determined by test at low altitude, 3300 feet or less) shall be less than those specified in these standards by four-tenths of one per cent of the specified rise for each 330 feet (100 meters) of altitude in excess of 3300 feet (1000 meters) at which the actual installation is to be made.

21-7 **Conditions Affecting Construction or Protecting Features.** Unusual conditions may require special construction or operation, and these should be brought to the attention of those responsible for the application, manufacture, and operation of the equipment. Among such unusual conditions are:

Exposure to damaging fumes or vapors.
Exposure to excessive moisture or dripping water.
Exposure to excessive dust, abrasive dust or magnetic dust.
Exposure to steam.
Exposure to salt air.
Exposure to abnormal vibration, shocks or tilting.
Exposure to unusual transportation or storage conditions.
Exposure to oil vapors.
Unusual space limitations.
Unusual insulation requirements.

DEFINITIONS

21-25 **Bushing.** A bushing is an insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

21-26 **Flashover of a Bushing.** Flashover of a bushing is the disruptive discharge through air or over the surface of a bushing from live parts to ground, produced by the application of voltage wherein the breakdown path becomes sufficiently ionized to maintain an electric arc.

21-27 **Withstand Test Voltage.** Withstand test voltage is the voltage which the bushing must withstand without flashover or other electrical failure when voltage is applied under specified conditions. For low-frequency voltage the values are expressed as rms and for a specified time; for impulse voltages the values are expressed in crest of a specified wave.

21-28 **Critical Impulse Flashover Voltage.** The critical impulse flashover voltage of a bushing under an impulse of a given wave shape and polarity is the crest value of that impulse when its amplitude is adjusted to cause flashover on 50 per cent of the applications.

RATING

21-50 **Rating.** The rating of an apparatus bushing shall include the following items:

(a) Rated voltage.
(b) Rated frequency.
(c) Rated continuous current.

21-51 **Rated Voltage.** The rated voltage of an apparatus bushing is the voltage at which it is designed to operate.

21-52 **Rated Frequency.** The rated frequency of an apparatus bushing is the frequency of the circuit for which it is designed.

21-53 **Rated Continuous Current.** The rated continuous current of an apparatus bushing is the current expressed in amperes which the bushing can carry continuously without exceeding the allowable temperature rise. (See paragraphs 21-75 and 21-76.)

HEATING

21-75 **Bushing Furnished as an Integral Part of the Apparatus.** When the bushing is furnished as an integral part of the apparatus, the thermal performance shall be such that it will meet the thermal requirements for the apparatus on which it is used as demonstrated by heat run on complete apparatus with bushing assembled, when such heat run is made.

21-76 **Bushing Furnished as a Separate Device**—When the bushing is furnished as a separate device or whenever it is necessary to make a heat run on an apparatus bushing separate from the apparatus, it shall be tested in accordance with the Test Code for Apparatus Bushings (Appendix I, Section H-3) and the following rules regarding temperature rise apply:

(a) The temperature rise over ambient air of the current carrying part of a bushing when tested with rated current shall not exceed 30C.

(b) The temperature rise over ambient air of other parts of a bushing accessible to mercury or alcohol thermometers shall (1) conform with Section 21-75 when it is known with which apparatus the bushing is to be used, and (2) shall not exceed 30C when tested with rated current if it is not known with which apparatus the bushing is to be used.

DIELECTRIC TESTS

21-100 **Dielectric Tests.** The standard dielectric test voltages for apparatus bushings shall be in accordance with the following Table I. Dielectric tests shall be made in accordance with the Test Code for Apparatus Bushings (Appendix I).

NAMEPLATE MARKINGS

21-125 **Nameplate Markings.** The following information shall appear on all apparatus bushing nameplates:

(a) Manufacturer's name and address.
(b) Manufacturer's type and designation number.
(c) Year of manufacture.
(d) Impulse withstand Kv.
(e) Rated voltage.
(f) Rated continuous current.
(g) Rated frequency (if suitable for frequencies up to 60 cycles, rated frequency may be omitted).

NOTE: On small bushings nameplates need not be used if impracticable. In such cases each bushing shall be marked in some conspicuous place with at least the catalog number.

(As the table of Standard Withstand Test Voltages for Apparatus Bushings has been superseded by ASA C37.4a-1954, the latter is here substituted for the older standard.)

TABLE 1

Electrical Characteristics

Voltage Class KV	Creepage Distance Minimum —Inches	60 Cy. Withstand		Impulse-Full Wave Dry Withstanding KV (1.5x40Ms)
		1 Min. Dry-Kv	10 Sec Wet Kv	
23*	17	70	70	150
34.5*	26.5	95	95	200
46*	35	120	120	250
69*	48.5	175	175	350
92TR	53	225	190	450
115	66	280	230	550
138	79	335	275	650
161	92	385	315	750
196	114	465	385	900
230	135	545	445	1050
287.5	170	680	555	1300

NOTE 1: If flashover tests are required, on bushings rated 23 kv to 69 kv, inclusive, a parallel test gap shall be used to limit the applied voltage to not more than 105 percent of the withstand voltage given in the table above.

NOTE 2: The voltage classification numbers given above are retained merely as reference numbers and are not necessarily nominal operating service voltages.

TR: For transformers only.

*These four sets of values also apply to Table 8 of C57.12a-1954, American Standard Requirements for Transformers, 67,000 Volts and Below; 501 through 10,000 Kva, 3 Phase; 501 through 5,000 Kva, 1 Phase.

APPENDIX

Test Code for Apparatus Bushings

General

SCOPE

A-1 This test code pertains to tests on apparatus bushings themselves apart from tests on the assembled apparatus.

CLASSIFICATION OF BUSHING TESTS

B-1 Routine Tests are dry one-minute low-frequency* withstand tests made by the manufacturer at the factory on a sufficient number of bushings in each lot to assure quality of manufacture.

B-2 Design Tests include a wet ten-second low-frequency withstand test and a dry impulse withstand test. They are made for design application data or on specific bushings at the request of the purchaser when specified and agreed upon.

TEST PROCEDURE

PREPARATION OF BUSHINGS FOR TESTS

C-1 Tests shall be made only on bushings assembled with all elements normally considered essential insulating parts of the bushing.

C-2 The bushing shall be clean.

C-3 Bushings suitable for vertical mounting shall be tested with the bushing mounted vertically on a relatively flat tank cover so as to prevent an arc from striking to the edge of the cover or to any grounded object other than grounded parts of the bushing or the relatively flat portion of the tank cover. Bushings not suitable for vertical mounting shall be tested under conditions approximating normal service.

C-4 Bushings may be subjected to routine tests under convenient conditions of immersion or without immersion. Bushings subjected to design tests should have expected conditions of immersion. For bushings with ground sleeves the ground sleeve may be immersed to any convenient depth. For bushings without ground sleeves the minimum expected immersion should be used.

C-5 For design tests, the test connection to the bushing shall leave the bushing terminal in a direction approximately parallel to the axis of the bushing for a distance not less than the arcing distance of the bushing, and no other objects, except the tank and cover, shall be close enough to the bushing to appreciably affect the test results.

ADJUSTMENT OF CONDITIONS FOR WET TEST

D-1 Precipitation

(a) Spray Nozzle

The bushing being tested shall be placed in an area supplied with a reasonably uniform artificial precipitation produced by a suitable number of spray nozzles of the design shown in Fig. 1, page 159, or equivalent.

(b) Direction of Spray

The spray shall be directed to strike the bushing downward at an angle of 45 degrees from the vertical and parallel to the vertical plane through its axis within practical limitations. In the case of large bushings, over 6 feet in length, the spray shall be 45 degrees from the vertical at the center of the bushing and as near to this angle at the ends as possible, consistent with good uniformity of precipitation throughout its length:

---

*In this Test Code, "low-frequency" is taken to mean any available frequency from 16 to 100 cycles.

(c) Rate of Precipitation

The standard rate of precipitation at the bushing shall be 0.2 inch per minute (5.08 mm) when measured as directed in paragraph D-2 below.

(d) Resistivity of the Spray Water

The standard resistivity of the spray water shall be 7000 ohms per inch cube (17800 ohms per cm cube) at the temperature at which the water strikes the bushing. The resistivity of the spray water shall not deviate more than 15 per cent from the standard. If water of the above resistivity is not readily available, water of other resistivity may be used, if suitable and agreed upon correction factors are applied.

(e) Temperature of Spray Water

The temperature of the spray water when it strikes the bushing shall not deviate more than 15C from room temperature.

NOTE: No exact data is available on the effect of variation in water temperature. Experience indicates, however, that normal variations in water temperature are unimportant provided the correct resistivity is maintained.

(f) Pressure of Spray Water

The spray water shall be delivered to the nozzles at a pressure of not less than 35 pounds per square inch (2.46 kg per square cm) and at not more than 60 pounds per square inch (4.22 kg per square cm) measured near the nozzle.

(g) Area Sprayed

The bushing shall be centrally located by inspection in a uniformly-sprayed area having a width at least 2 times and a length at least 1¼ times that of the bushing being tested.

(h) Location of Spray Equipment

Spray nozzles, supply pipes, and the supporting structure for them shall be located not closer than three feet from the bushing and in the case of large bushings where this minimum clearance is not sufficient, they shall be located far enough from the bushing so that no flashover shall occur to them during test.

D-2 Measurement of Precipitation

(a) Measuring Vessel

The vessel used to collect the water for measuring the precipitation, resistivity, and temperature, shall have a top opening of 6 to 12 inches inside diameter with an upstanding rim at least 1 inch high having an edge thickness not exceeding 1/16 inch.

(b) Position of Measuring Vessel

1. Bushings having a height or length not exceeding 18 inches: During measurements of precipitation the measuring vessel shall be held opposite the top of the bushing in line between the spray nozzle and the axis of the bushing and at a point approximately three inches outside the largest diameter of the insulating element. The vessel shall be held with its top opening horizontal.

2. Bushings having a height or length exceeding 18 inches: Separate measurements shall be made opposite the top, middle and bottom of the bushing with the measuring vessel held in a line between the spray nozzles and the axis of the bushing, the side of the rim of the vessel being approximately three inches outside the largest diameter of the bushing. The vessel shall be held with its top opening horizontal.

(c) Duration of Individual Measurements

Final measurements of the rate of precipitation shall be accurately timed and shall be of a duration of at least one minute for each measurement.

(d) Tolerance on Rate of Precipitation

For precipitation measured in accordance with par. (b) part 1, the measurement shall not deviate more than 10 per cent from the standard.

For precipitation measured in accordance with par. (b) part 2, the average of the three measurements shall not deviate more than 10 per cent from the standard and no single measurement shall deviate more than 25 per cent from the standard.

(e) Constancy of Spray Conditions

Care shall be exercised to see that the nozzle pressure and other spray conditions remain practically constant while the tests are being made after final adjustments of the precipitation are completed.

D-3 Preparation of the Bushing

(a) Preliminary Wetting

The entire surface of the bushing shall be given a thorough preliminary wetting not more than one minute prior to placing in the spray, using water having the same characteristics as the spray water.

STANDARD TEST CONDITIONS

E-1 Standard atmospheric and precipitation conditions are as follows:

Air Temperature	77F	25C
Barometric Pressure	29.92 in.	760 mm
Humidity-Vapor Pressure	0.6085 in.	15.45 mm
Water Resistivity	7000 ohm/in^3	17800 ohm/cm^3
Rate of Precipitation	0.2 in./min	5.08 mm/min
Angle of Precipitation	45 deg.	45 deg.

Where test conditions differ from those above, suitable corrections shall be made as outlined in Sections F-1 and F-2.

E-2 Rate of Voltage Application for Low-Frequency Tests

The initial applied voltage may be quickly raised to 75 per cent of the expected test value. The continued rate of voltage increase shall be such that the time to reach the expected test voltage shall be between 5 and 30 seconds after the 75 per cent value has been reached.

E-3 Duration of Voltage Application for Low-Frequency Withstand Tests

The required voltage shall be held for the specified time after the full value has been reached.

E-4 Application of Impulse Test Voltage

The 1.5 x 40 microsecond wave shall be used for impulse tests. The time to crest shall be measured from the virtual time zero and shall not exceed 2.0 microseconds. The time to 0.5 crest value point on the tail of the wave shall be measured from the virtual time zero and shall not be less than 40 microseconds.

Note: The virtual time zero is the intersection of the zero voltage line and a line drawn through points on the front of the wave at 30 per cent and 90 per cent of the crest value.

E-5 Testing Equipment and Voltage Measurements

The character of the test equipment and the method of measuring voltage shall conform to AIEE Standard No. 4, "Standards for the Measurement of Test Voltage in Dielectric Tests."

CORRECTION FACTORS

F-1 Correction Factor (D) for Variation in Air Density

The air temperature at the time of test should be between 50F and 104F, (10C and 40C).

The correction factor for variation in air density is determined as follows:

$$D = \frac{18B}{459 + F} = \frac{0.392\,b}{273 + C}$$

D = Correction Factor
B = Barometric pressure in inches
b = Barometric pressure in millimeters
F = Temperature in degrees Fahrenheit
C = Temperature in degrees Centigrade

F-2 Correction Factor (H) for Variation in Vapor Pressure-Humidity

Vapor pressure at the time of test should preferably be between 0.3 inch and 0.7 inch (7.6 mm and 18.0 mm), to minimize the errors when corrections for vapor pressure are approximated by the use of humidity correction factor (H) taken from curves, B, D, and E, of "Recommendations for High-Voltage Testing," Elec. Eng'g., Oct. 1940, pages 601-602. No correction for humidity shall be made on wet tests.

Note: Correction curves strictly applicable to bushings are not as yet available and the curves mentioned may be used until data are obtained upon which to base new correction curves.

F-3 Recorded Data

All data used in determining correction factors shall be recorded.

ROUTINE TESTS

G-1 Dry One-Minute Low-Frequency Withstand Test

(a) The bushing should be tested in accordance with paragraphs E-1 through E-5.

(b) No adjustment for variation from standard atmospheric conditions shall be made.

(c) The routine test shall be made after all design.

DESIGN TESTS

H-1 Wet 10-Second Low-Frequency Withstand Test

(a) The bushing shall be tested in accordance with paragraphs D-1 through D-3 and E-1 through E-5.

(b) The applied voltage shall be the specified voltage multiplied by correction factor D as determined from paragraphs F-1 through F-3.

H-2 Impulse Withstand Test

(a) The bushing shall be tested in accordance with paragraphs E-1 through E-5.

(b) The required impulse values must be met with either positive or negative impulse waves.

(c) Three consecutive impulses shall be applied to the bushing. If a flashover does not occur, the bushing shall be considered as having met the test.

If two or three of the applied impulse waves cause flashover, the bushing shall be considered as having failed.

If one of the applied impulses causes flashover, three additional impulses shall be applied. If flashover does not occur, the bushing shall be considered as having met the test.

(d) The applied voltage shall be not less than the specified voltage multiplied by D/H as determined from paragraphs F-1 through F-3.

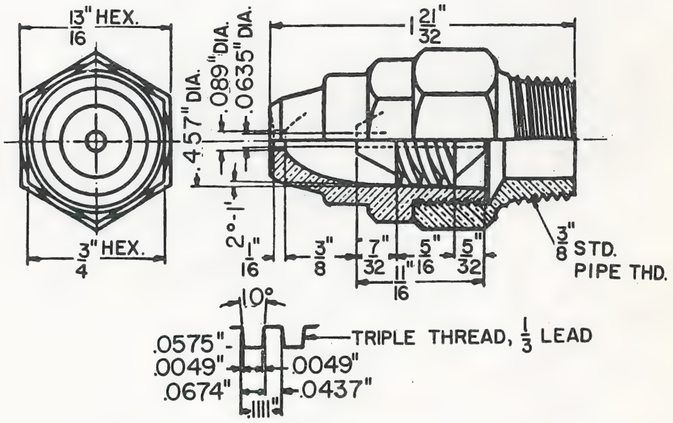
H-3 Thermal Tests

(a) Mounting and Current Connections

For heat runs, apparatus bushings shall be mounted in the expected operating position with the expected condition of oil immersion. Current-carrying connections to the bushing terminals shall be no bulkier than necessary and should duplicate as closely as possible the type of connection expected in service.

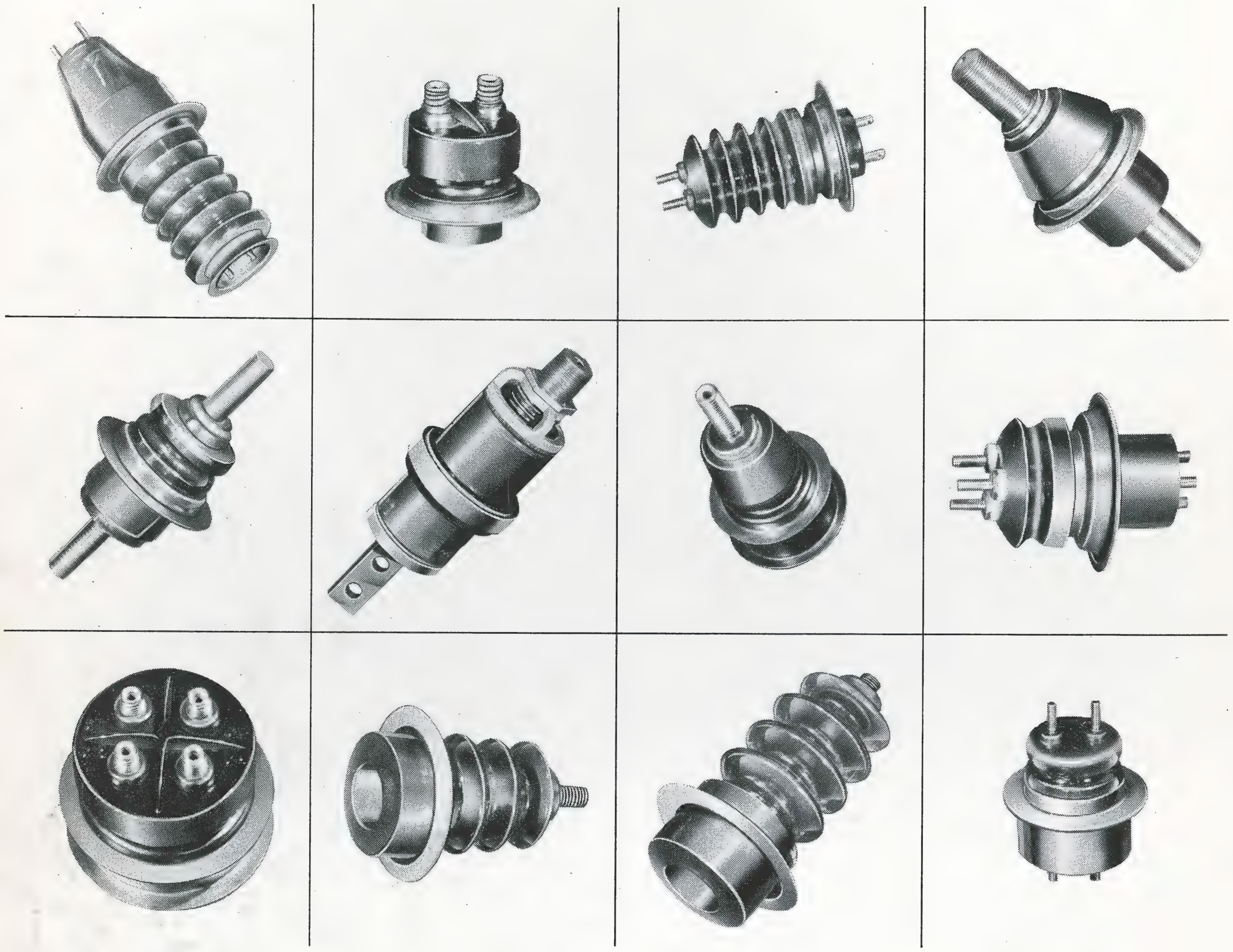
(b) Ambient Temperature

The test may be made at any ambient temperature, preferably not below 10C. The average temperature of immersion oil, if used, shall be at approximately the temperature of the ambient air. It shall be assumed that the temperature rise is the same for all ambient temperatures between the limits of 10C and 40C.



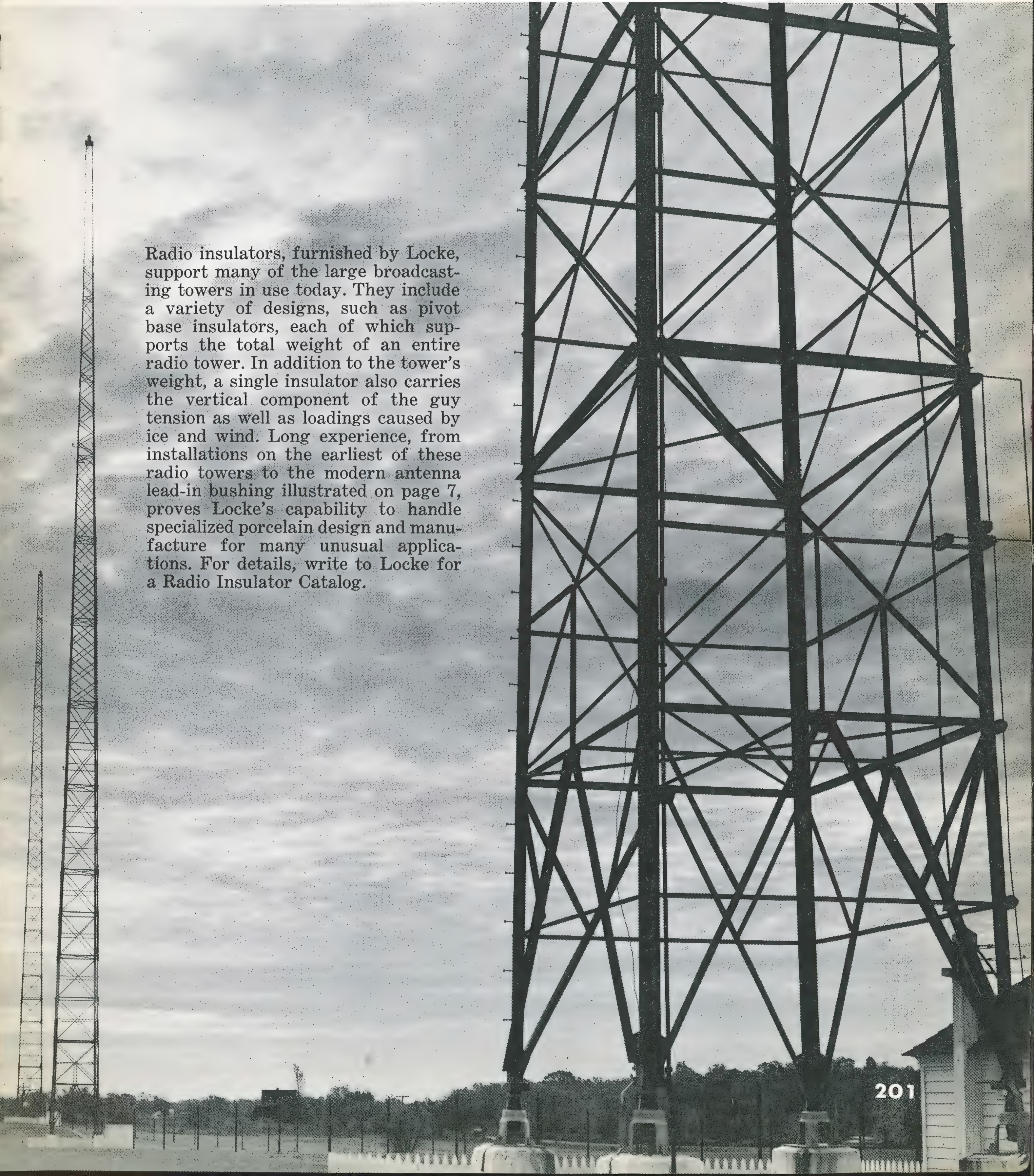
Detail of Threads on Internal Element
Fig. 1

CAST GLASS BUSHINGS



In ratings up to the 15 KV power transformer impulse level and for currents up to 800 amps., Locke Cast Glass Bushings permit the successful design of hermetically sealed electric apparatus. They are heatproof, leakproof and shockproof for use in vital communication and commercial applications where severe operating conditions are met, and are available in a wide variety of sizes and shapes in both single and multi-conductor designs. For information, ask for Bulletin LA-107.

RADIO INSULATORS



Radio insulators, furnished by Locke, support many of the large broadcasting towers in use today. They include a variety of designs, such as pivot base insulators, each of which supports the total weight of an entire radio tower. In addition to the tower's weight, a single insulator also carries the vertical component of the guy tension as well as loadings caused by ice and wind. Long experience, from installations on the earliest of these radio towers to the modern antenna lead-in bushing illustrated on page 7, proves Locke's capability to handle specialized porcelain design and manufacture for many unusual applications. For details, write to Locke for a Radio Insulator Catalog.

INSULCONE FOR IMPROVED OPERATIONS IN CONTAMINATED AREAS

A Silicone Base Fluid for treating Insulators to improve operation in contaminated areas.

Insulcone* has been used with success in retarding the effect of some types of contamination on porcelain insulators. While it will not solve all contamination problems, it is recommended where atmospheric contaminants impair the proper function of insulators.

EASY APPLICATION

Insulcone is a liquid which is applied to the insulator by brushing, dipping or spraying.

ACTION IMPROVES OPERATION— MAKES CLEANING EASY

The film of Insulcone retards the spreading of dissolved contaminants over the insulator surface. By "bunching" the moisture in droplets, it retards formation of a continuous electrolytic film. Continuous low resistance leakage current paths are broken up, avoiding excessively distorted voltage gradients. By retarding bonding action of contaminants, the formation of firm deposits is deterred. This makes natural and manual cleaning of insulators much easier.

The chemical stability of Insulcone, superior to ordinary waxes, makes it highly resistant to weathering and to the charring action of leakage currents and corona streamers. It has high resistance to heat, cold, chemicals and weathering, yet retains the flexibility and plasticity of organic liquids.

TESTS PROVES ADVANTAGES

1. Higher foul weather flashover values.
2. Decreased leakage currents, with resulting decreases in pole top fires, pin burning, radio interference and hardware corrosion.
3. Longer time between periods when insulators, operating under conditions of severe contamination, must be cleaned.
4. Easier cleaning because of reduced bonding action between contaminant and insulator surface.
5. All resulting in better service, improved performance, less frequent changes, and lower maintenance costs.

Insulcone is available in 1 gallon, 5 gallon and 55 gallon containers.

For further information on Cleaning of Insulator Surfaces, see page 15 or write to Locke for copies of an AIEE paper "Silicone Fluid Surface Treatment for Insulators Operating in Contaminated Atmospheres."

LOCKEBRITE INSULATOR CLEANER

LOCKEBRITE* is a specially compounded powder-type cleaner which quickly removes from insulators all types of dirt deposits, except heavily encrusted cement. It works rapidly and easily, and cannot harm glaze, galvanizing or cement. It has a neutral base and contains no irritating material, making it safe to use freely, without danger to skin or clothing.

APPLICATION

Lockebrite is used in the same way as other powder cleaners. It does not matter how serious the dirt condition is. Even contamination on old insulators used in tunnels or combined steam and electric railroads yields readily.

In cases where the operating and atmospheric conditions were so severe that the glaze actually became pitted, Lockebrite removed all signs of contamination and left the remaining glaze as bright and clean as on the day the insulators left the factory.

It is packed in half-gallon cartons and is stocked at the factory.

*T. M., General Electric Co.

SPECIAL PORCELAIN

Industrial application of porcelain insulators requires an infinite variety of special shapes and designs. Locke engineers draw upon many years of successful experience in the design of special apparatus porcelain insulators to fit specific customer requirements. Whether you need potheads, fuse holders, cover bushings, cut-out boxes or specially formed porcelain insulators, we can supply them to your specifications or will design them for you to meet your insulation problems. Call us for engineering assistance. A helpful booklet, "How to design Apparatus Porcelain," is available on request.

USEFUL DATA

The following pages include a variety of facts and data which, we hope, will be generally helpful to the user of this catalog.

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AMERICAN STANDARD INSULATOR TESTS

AIEE 41—1944 A.S.A. C29.1—1944

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1. SCOPE AND PURPOSE

1.1 These standards comprise a manual of test procedures to be followed in making tests to determine the characteristics of insulators to be used on electric power systems. They are not intended to include test procedure for apparatus bushings.* Since these standards are not intended to be insulator specifications, the individual tests may be made a part of an insulator specification only when specifically designated in contract specifications. In all cases where these standards include high voltage measurements, the methods, equipment, and technique shall be in accordance with American Standards for Measurement of Test Voltage in Dielectric Tests, C68.1-1942 or latest revision thereof.

2. DEFINITIONS

2.1 For the purpose of these specifications the following definitions are used to clarify the procedure.

2.2 Insulators and Parts

2.2.1 **Shell.** A shell is a single insulating member without cement or other connecting devices.

2.2.2 **Pin-Type Insulator.** A pin-type insulator is any insulating unit, the function of which is to support rigidly and insulate a line conductor as on a crossarm.

2.2.3 Suspension Insulator

2.3.3.1 *Unit.* A suspension insulator unit is an assembly of 1 or more shells with the necessary metal parts for flexibly attaching other insulators or hardware.

2.2.3.2 *String.* A suspension insulator string is a chain of 2 or more units coupled together.

2.2.4 Switch and Bus Insulator. (Indoor and Outdoor)

2.2.4.1 *Unit.* A switch and bus insulator unit is the assembly of 1 or more insulating elements with attached metal parts, the function of which is to support rigidly a conductor on a structure or base member.

2.2.4.2 *Stack.* A stack is a rigid assembly of 2 or more switch and bus units.

2.2.5 **Guy Insulator.** A guy insulator is an insulating element, generally of elongated form with two transverse holds or slots used, for the purpose of insulating a guy or cable.

2.2.6 **Spool Insulator.** A spool insulator is an insulating element of generally cylindrical form having an axial hole and a circumferential groove or grooves for the attachment of a conductor.

2.2.7 **Bushing.** A bushing is any insulating unit, usually of elongated form with an axial hole, the function of which is to insulate a conductor passing through a barrier.

2.2.8 **Tube.** A tube is a single element bushing without hardware.

2.2.9 Unit and Shell Identification

2.2.9.1 *Insulating Units.* Insulating units when used in a string or stack, and the individual shells of multi-part roof and wall bushings shall be referred to by consecutive numbers starting with the energized electrode.

2.2.9.2 *Individual Shells.* The individual shells of multi-part assemblies, other than roof and wall bushing assemblies, shall be referred to by consecutive numbers, starting with the uppermost shell in the normal position.

2.3 Low-Frequency Voltages

2.3.1 **Low Frequency.** "Low frequency" as used in these standards is understood to mean any frequency between 15 and 100 cycles per second. Any available commercial frequency within this range will be acceptable for making low-frequency tests outlined in these standards.

2.3.2 **Low-Frequency Dry-Flashover Voltage.** The low-frequency dry-flashover voltage is the root-mean-square (rms) voltage causing a sustained disruptive discharge through the air between electrodes of a clean, dry test specimen, the test being made as described in 4.1.

2.3.3 **Low-Frequency Wet-Flashover Voltage.** The low-frequency wet-flashover voltage is the root-mean-square (rms) voltage causing a sustained disruptive discharge through the air between electrodes of a clean, wet test specimen, the test being made as described under 4.2.

2.3.4 **Low-Frequency Withstand Voltage.** A low-frequency withstand voltage of a test specimen is a root-mean-square (rms) low-frequency voltage which does not cause a sustained disruptive discharge when applied to the test specimen for a specified time.

2.3.5 **Low - Frequency Rated - Withstand Voltage.** The low-frequency rated-withstand voltage of a test specimen is the root-mean-square (rms) low-frequency voltage which can be applied under specified conditions without sustained disruptive discharge on the test specimen.

2.3.6 **Puncture Voltage.** The puncture voltage of a test specimen is the voltage at which the test specimen is electrically punctured, the test being made as described under 4.7.

2.4 Impulse Voltages

2.4.1 **Impulse-Flashover Voltage.** The impulse-flashover voltage of a test specimen is the crest voltage of a wave causing a complete disruptive discharge through the air between electrodes of the test specimen, the test being made as described under 4.3.

2.4.2 **Impulse Critical-Flashover Voltage.** The impulse critical-flashover voltage of a test specimen is the crest value of a wave causing flashovers on 50 percent of the applications, the test being made as described under 4.3.

2.4.3 **Impulse-Withstand Voltage.** An impulse-withstand voltage of a test specimen is the crest value of an applied impulse voltage which does not cause a complete disruptive discharge on the test specimen.

2.4.4 **Impulse Rated-Withstand Voltage.** The impulse rated-withstand voltage of a test specimen is the crest value of an impulse voltage which can be applied under specified conditions without complete disruptive discharge on the test specimen, the test being made as described under 4.4.

2.5 Mechanical Loading

2.5.1 **Ultimate Mechanical Strength.** The ultimate mechanical strength of an insulator is the loading in pounds at which any part of the insulator fails to perform its function of providing a mechanical support without regard to electrical failure, the test being made as described under 5.1.

2.5.2 **Combined Mechanical and Electrical Strength.** The combined mechanical and electrical strength of an insulator is the loading in pounds at which any part of the insulator fails to perform its function either electrically or mechanically, when voltage and mechanical stress are applied simultaneously as described under 5.2.

2.5.3 **Time-Load Test.** A time-load test is a continuous mechanical loading test, held for a prescribed time, at a fixed load value followed by momentary application of flashover voltage to detect electrical failure.

2.5.4 **Mechanical Impact Strength.** The mechanical impact strength of an insulator is the impact blow in inch-pounds which the insulator can withstand without chipping, breaking, cracking, or being otherwise damaged, the test being made as described under 5.1.2.2.

2.6 Miscellaneous

2.6.1 **Leakage Distance.** The leakage distance of an insulator is the sum of the shortest distances measured along the surface of the insulator between the conductive parts when arranged for dry-flashover test. Surfaces coated with semi-conducting glaze shall be considered as effective leakage surfaces, and leakage distance over such surfaces shall be included in the leakage distance.

2.6.2 **Dry-Arcing Distance.** The dry-arcing distance of an insulator is the sum of the shortest distances, through air or over the surface, between the live metallic and grounded parts of an insulator when arranged for dry-flashover test.

2.6.3 **Radio-Influence Voltage.** The term "radio-influence voltage" is used to designate the radio frequency voltage measured with a noise meter in accordance with Joint Coordination Committee on Radio Reception of Edison Elec-

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* For apparatus bushings see American Standards for Apparatus Bushings and Test Code for Apparatus Bushings, C76.1-1943 or latest revision thereof.

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tric Institute, National Electrical Manufacturers Association and Radio Manufacturers Association as set forth in EEI Publication G9 (NEMA Publication 107, RMA Engineering Bulletin 32) of February, 1940.

2.6.4 **Radio-Influence Characteristics.** The radio-influence voltages associated with several different values of normal-frequency potential across the insulator shall be known as the radio-influence characteristics of that insulator.

3. SPECIMEN MOUNTING FOR ELECTRICAL TEST

3.1 Suspension Insulators

3.1.1 **Supporting Method.** The test specimen (unit or string) shall be suspended vertically by the makers' standard crossarm suspension hardware carried at the end of a grounded wire or suitable conductor suspended so that the vertical distance from the uppermost point of the insulator hardware to the supporting structure shall be not less than 3 feet.

3.1.2 **Bottom Electrode.** The bottom electrode or conductor shall be a straight smooth rod or tube having an outside diameter of not less than 1 inch, nor more than 1½ percent of the specimen dry-arcing distance. It shall be coupled to the lower integral fitting of the specimen so that the distance from the lowest edge of the insulator shell to the upper surface of the electrode shall be between 0.5 and 0.7 of the diameter of the lowest insulator. The conductor shall be horizontal and at right angles to the axis of the test specimen. The conductor shall be of such length that arc-over will not be initiated at the electrode ends.

3.1.3 **Proximity of Other Objects.** No grounded objects other than grounded parts of the test assembly shall be nearer the test specimen or live electrodes than 1½ times the specimen dry-arcing distance, with a minimum allowable spacing of 3 feet.

3.2 Pin-Type Insulators

3.2.1 **Mounting Arrangement (Crossarm).** The supporting crossarm shall be a horizontal, straight, smooth, grounded, metallic tube or structural member having a horizontal width not less than 3 inches nor more than 6 inches. It shall be of such length that arc-over will not be initiated at its ends.

3.2.2 **Mounting Pin (If Required).** When a separable pin is required, the test specimen shall be mounted vertically on a 1-inch-diameter metal pin of such length that the shortest dry-arcing distance from the upper electrode and connected metallic parts to the supporting crossarm shall be 25 percent greater than the similar distance to the pin. The pin shall be coaxial with the insulator. Insulators having integrally assembled means for mounting on a crossarm shall be mounted on the test crossarm directly as in service.

3.2.3 **Top Electrode.** The top electrode or conductor shall be a horizontal round rod or tube placed at right angles to the supporting crossarm and of a diameter not less than 0.5 inch. It shall be of such length that arc-over will not be initiated at its ends. The conductor shall be placed in the top wire groove of the insulator or any other means provided for the conductor support as in service. If a tie wire is to be used, the conductor rod or tube shall be secured by means of at least 1 turn of wire having a diameter not smaller than No. 8 Awg, the ends being closely wrapped about the rod on each side of the insulator.

3.2.4 **Proximity of Other Objects.** No grounded objects other than grounded parts of the test assembly shall be nearer the test specimen or live electrodes than 1½ times the specimen dry-arcing distance, with a minimum allowable spacing of 3 feet.

3.3 Switch and Bus Insulators

3.3.1 **Mounting Arrangement.** The test specimen shall be mounted vertically upright on a horizontal, grounded 10-inch channel, with the channel flanges projecting down. A sub-base may be used if required. The supporting channel shall be of such length that arc-over will not be initiated at its ends, and its top surface shall be not less than 3 feet above the ground.

3.3.2 **Top Electrode.** The top electrode or conductor shall be a horizontal round rod or tube at right angles to the supporting channel and of a diameter approximately 5 percent of the specimen dry-arcing distance within the limits of 4½ inches, (4-inch iron pipe size) maximum, and ½-inch minimum. The length of the conductor shall be such that arc-over shall not be initiated at its ends. It shall be mounted directly in contact with the top integral fitting of the test specimen and with its horizontal axis in the same vertical plane as the vertical axis of the specimen.

3.3.3 **Proximity of Other Objects.** No grounded objects other than grounded parts of the test assembly shall be nearer the test specimen or live electrodes than 1½ times the specimen dry-arcing distance, with a minimum allowable spacing of 3 feet.

3.4 Guy Insulators

3.4.1 **Mounting Arrangement.** The test specimen shall be mounted in a position with its major axis at 45 degrees from the vertical, using attachment fittings used in service or a flexible metal conductor of approximately 75 percent of the hole diameter of the specimen which shall be clamped back on itself with standard guy clamps. The clamps shall be spaced from the test specimen at a distance not less than the specimen length. Mechanical tension shall be applied to the specimen sufficient to avoid appreciable sag in the set-up. The lower attaching fitting or guy-strand section shall be grounded.

3.4.2 **Proximity of Other Objects.** No grounded objects other than grounded parts of the test assembly shall be nearer the test specimen or live electrodes than 1½ times the dry-arcing distance of the specimen, with a minimum allowable spacing of 1 foot.

3.5 Dead-End and Spool Assemblies

3.5.1 Mounting Arrangement

3.5.1.1 *Dead-End Assemblies Complete with Hardware.* The test specimen may be mounted with the axis of the insulating spool either horizontal or vertical on a suitable grounded support as used in service.

3.5.1.2 *Dead-End Spools, Insulating Element Only.* The spool shall be mounted between and in contact with 2 smooth metallic straps 1½ inches wide and of any suitable thickness. A rod of suitable diameter shall pass through the axial hole of the test specimen and 1 end of each of the straps. The straps shall extend in one direction from the rod and remain parallel to each other for a distance from the test specimen not less than the height of the specimen. The other end of the straps shall be suitably connected to a grounded support.

3.5.3 **Live Electrode.** The live electrode shall consist of 1 turn of No. 8 Awg conductor placed around the wire groove and served back on itself. This conductor shall be carried away from the test specimen parallel to and in an opposite direction to the supporting straps or design hardware.

3.5.4 **Proximity of Other Objects.** No grounded objects other than grounded parts of the test assembly shall be nearer the test specimen or live electrodes than 1 foot.

3.6 Roof and Wall Bushings

3.6.1 Vertical Mounting

3.6.1.1 *Mounting Arrangement.* The specimen, complete with its assembled hardware as used in service, shall be supported with its axis vertical. A flat, smooth, metallic plate shall be secured to the flange of the test specimen. This plate shall extend radially away from the bushing in all directions for a distance such that arc-over will not be initiated at the outer edges. The plate shall be connected to ground by means of a conductor which shall extend radially away from the test specimen in the plane of the plate for a distance not less than twice the minimum dry-arcing distance of the test specimen.

3.6.1.2 *Test Lead.* The test lead shall extend coaxially away from the bushing for a distance not less than the minimum dry-arcing distance of the test specimen.

3.6.1.3 *Proximity of Other Objects.* No grounded objects other than grounded parts of the test assembly shall be nearer the test specimen or live electrodes than 1½ times the minimum dry-arcing distance of the test specimen.

3.6.2 Horizontal Mounting

3.6.2.1 *Mounting Arrangement.* The test specimen, complete with assembled hardware as used in service, shall be supported with its axis in the horizontal position and shall have a flat, smooth, metallic plate secured to its flange. This plate shall extend radially away from the test specimen for a distance such that arc-over will not be initiated at its outer edges. This plate shall be grounded by a conductor extending radially from the test specimen in the plane of the plate for a distance not less than 1½ times the minimum dry-arcing distance of the specimen.

3.6.2.2 *Test Lead.* The test lead shall be attached to the conductor of the test specimen so that it will extend coaxially away from it for a distance not less than the minimum dry-arcing distance of the test specimen.

3.6.2.3 *Proximity of Other Objects.* No grounded objects other than grounded parts of the test assembly shall be nearer the test specimen or live electrodes than 1½ times the minimum dry-arcing distance of the test specimen.

3.7 Tubes

3.7.1 Mounting Arrangement. The wall section or normally grounded area of the outside of the specimen shall be covered with a close-fitting grounded conductor. The specimen shall be horizontally suspended or otherwise horizontally supported by suitable flat, grounded, conducting barriers through which the specimen extends, its axis being perpendicular to the plane of the barriers. One barrier shall be located at each end of the normally grounded area of the specimen which has been covered with the close-fitting grounded conductor. The barrier shall have a width or diameter not less than twice the projection of the specimen beyond the barrier plus the diameter of the tube.

3.7.2 Central Electrode. The energized electrode shall consist of a metal rod or tube placed coaxially with the hole of the specimen and extending through it. The rod or tube shall be of such dimensions as to give approximately ½-inch air space between the outside of the conductor and the inside wall of the specimen at all points. The ends of the hole in the specimen shall be closed by a suitable conducting means having approximately the same dimensions as the hole and arranged to center the conductor in the specimen. The conductor shall extend beyond the bushing at each end so that arc-over will not be initiated at its ends. In the case of specimens having holes of a width or diameter smaller than 1⅜ inches, the conductor shall be approximately ½ the hole width or diameter.

3.7.3 Proximity of Other Objects. No grounded objects other than grounded parts of the test assembly shall be nearer the test specimen or live electrodes than 1½ times the dry-arcing distance of the specimen when prepared as described above.

4. ELECTRICAL TESTS

4.1 Low-Frequency Dry-Flashover Test

4.1.1 Specimen Mounting. The specimen mounting for dry-flashover test shall be in accordance with 3.1 through 3.7.3, above.

4.1.2 Voltage Application. The initial applied voltage may be quickly raised to approximately 75 percent of the expected average dry-flashover value. The continued rate of voltage increase shall be such that the time to flashover will be not less than 5 seconds nor more than 30 seconds after 75 percent of the flashover value is reached.

4.1.3 Dry-Flashover Voltage Value. The dry-flashover voltage value of a specimen shall be the arithmetic mean expressed in rms volts, of not less than 5 individual flashovers taken consecutively. The period between consecutive flashovers shall be not less than 15 seconds nor more than 5 minutes.

4.1.4 Corrections

4.1.4.1 *Standard Conditions.* Dry-flashover values shall be corrected to the following standard conditions:

Barometer	29.92 in. (760 mm)
Temperature	77 F (25 C)
Vapor Pressure	0.6085 in. (15.45 mm)

4.1.4.2 *Air Density.* The dry-flashover value shall be corrected to standard air density in accordance with American Standards for Measurement of Test Voltage in Dielectric Tests, ASA C68.1-1942 or latest revision thereof. The relative air density (δ) can be obtained by the formulas:

$$\delta = \frac{17.9\ p_b}{459 + t}$$

where p_b is expressed in inches of mercury and t in degrees F

$$\delta = \frac{0.392\ p_b}{273 + t}$$

where p_b is expressed in millimeters of mercury and t in degrees C

δ = Relative air density

t = Room temperature

p_b = Barometric pressure

4.1.4.3 *Humidity.* The dry-flashover value shall be corrected to standard humidity conditions in accordance with the tentative curves shown in Figure 1. The curves given are for suspension, switch and bus, and pin-type insulators. Curves are not available for bushings and other types.

The vapor pressure shall be determined by the following procedure:

Humidity shall be measured with wet and dry bulb thermometers, the air being circulated past the thermometers at a velocity of 3 meters (9.84 feet) or more per second, or by the sling psychrometer. The measurements shall be reduced to vapor pressure with the assistance of the Smithsonian Meteorological Tables or by the following formulas:

$$p_h = p_s - 0.000367\ p_b\ (t - t')\left(1 + \frac{t' - 32}{1571}\right)$$

where p_h and p_s are in inches and t in degrees F

$$p_h = p_s - 0.000660\ p_b\ (t - t')\ (1 + 0.00115\ t')$$

where p_h and p_s are in millimeters and t in degrees C

p_h = Vapor pressure

p_s = Pressure of saturated aqueous vapor at temperature t'

t = Temperature of air

t' = Wet bulb temperature of air

p_b = Barometric pressure

4.1.5 Probable Variation. Due to differences in atmospheric and other uncontrollable conditions, even with properly standardized equipment, a variation of ± 5 percent from the probable true average dry-flashover value may be expected in tests conducted in one laboratory, and ± 8 percent in values obtained in tests conducted in different laboratories. Larger variations may be expected on bushings.

4.2 Low-Frequency Wet-Flashover Test

4.2.1 Specimen Mounting. The specimen mounting for wet-flashover test shall be in accordance with 3.1 through 3.7.3, above.

4.2.2 Precipitation

4.2.2.1 *Spray Nozzles.* The insulator being tested shall be placed in an area supplied with a reasonably uniform artificial precipitation produced by a suitable number of spray nozzles.

4.2.2.2 *Direction of Spray.* The spray shall be so directed as to strike the insulator downward at an angle of 45 degrees from the vertical and parallel to the vertical plane through its axis within practical limitations. In the case of large specimens, more than 6 feet in length, the spray shall be at 45 degrees from the vertical at the center of the specimen and as near to this angle at the ends as possible, consistent with good uniformity of precipitation throughout its length.

4.2.2.3 *Rate of Precipitation.* The standard average rate of precipitation at the specimen shall be 0.2 inch (5.08 millimeters) per minute when measured as directed in 4.2.3.

4.2.2.4 *Resistivity of Spray Water.* The standard resistivity of the spray water shall be 7,000 ohms per inch cube (17,800 ohms per centimeter cube) at the temperature at which the water strikes the specimen. The resistivity of the spray water shall not deviate more than 15 percent from the standard.

4.2.2.5 *Temperature of Spray Water.* The temperature of the spray water when it strikes the specimen shall not deviate more than 27 F (15 C) from room temperature.

NOTE: No exact data are available on the effect of variation in water temperature. Experience indicates, however, that normal variations in water temperature are unimportant provided the correct resistivity is maintained.

4.2.2.6 *Pressure of Spray Water.* The spray water shall be delivered to the nozzles at pressure of not less than 35 pounds per square inch (2.46 kilograms per square centimeter) and at not more than 60 pounds per square inch (4.22 kilograms per square centimeter) measured near the nozzle.

4.2.2.7 *Area Sprayed.* The specimen shall be centrally located by inspection in an area uniformly sprayed having a width at least 2 times and a length at least 1¼ times that of the specimen being tested.

4.2.2.8 *Location of Spray Equipment.* Spray nozzles, supply pipes, and the supporting structure for them shall be located not closer than 3 feet from the specimen and in the case of large specimens where this minimum clearance is not sufficient, they shall be located far enough from the specimen so that no arc will occur to them during test.

4.2.3 Measurement of Precipitation

4.2.3.1 *Measuring Vessel.* The vessel used to collect the water for measuring the precipitation, resistivity, and temperature shall have a top opening 6 to 12 inches inside diameter with an upstanding rim at least 1 inch high having an edge thickness not exceeding 1/16 inch.

4.2.3.2 *Position of Measuring Vessel*

4.2.3.2a **Specimens Having a Height or Length Not Exceeding 18 Inches.** During measurements of precipitation the measuring vessel shall be held opposite the top of the insulating unit of the specimen in line between the spray nozzle and the axis of the specimen and at a point approximately 3 inches outside the largest diameter of the insulating element. The vessel shall be held with its top opening horizontal.

4.2.3.2b **Specimens Having a Height or Length Exceeding 18 Inches.** Separate measurements shall be made opposite the top, middle, and bottom of the insulating element or elements with the measuring vessel held in a line between the spray nozzles and the axis of the specimen, the side of the rim of the vessel being approximately 3 inches outside the largest diameter of the specimen. The vessel shall be held with its top opening horizontal.

4.2.3.3 *Duration of Individual Measurements.* Final measurements of the rate of precipitation shall be accurately timed and shall be of a duration of at least 1 minute for each measurement.

4.2.3.4 *Tolerances on Rate of Precipitation.* For precipitation measured in accordance with 4.2.3.2a, the measurement shall deviate not more than 10 percent from the standard.

For precipitation measured in accordance with 4.2.3.2b, the average of the 3 measurements shall deviate not more than 10 percent from the standard, and no single measurement shall deviate more than 25 percent from the standard.

4.2.3.5 *Constancy of Spray Conditions.* Care shall be exercised to see that the nozzle pressure and other spray conditions remain practically constant while the tests are being made after final adjustments of the precipitation are completed.

4.2.4 Preparation of Specimen

4.2.4.1 *Preliminary Wetting.* At not more than 1 minute prior to placing the insulator in the spray, the entire surface of the insulator shall be given a thorough preliminary wetting either by immersion, by spraying in an inverted position, or by using a hose on the insulator in its test position. Water used for preliminary wetting shall have the same resistivity as the spray water.

4.2.5 Flashover Measurements

4.2.5.1 *Voltage Application.* At not less than 1 minute after the final adjustment of the spray, the applied voltage may be raised quickly to approximately 75 percent of the expected average wet-flashover value. The continued rate of voltage increase shall be such that the time to flashover will be not less than 5 seconds nor more than 30 seconds after 75 percent of the flashover value is reached.

4.2.5.2 *Wet-Flashover Voltage Value.* The wet-flashover voltage value of a specimen shall be the arithmetic mean expressed in rms volts of not less than 5 individual flashovers taken consecutively. The period between consecutive flashovers shall be not less than 15 seconds nor more than 5 minutes.

4.2.6 Corrections

4.2.6.1 *Standard Conditions.* Wet-flashover values shall be corrected to the following standard conditions:

Barometer	29.92 in. (760 mm)
Temperature	77 F (25 C)

4.2.6.2 *Air Density Correction.* The wet-flashover value shall be corrected to standard air density in accordance with American Standards for Measurement of Test Voltage in Dielectric Tests, C68.1-1942 or latest revision thereof. The relative air density can be obtained by the following formulas:

$$\delta = \frac{17.9\, p_b}{459 + t}$$

where p_b is expressed in inches of mercury and t in degrees F

$$\delta = \frac{0.392\, p_b}{273 + t}$$

where p_b is expressed in millimeters of mercury and t in degrees C

δ = Relative air density
t = Room temperature
p_b = Barometric pressure

4.2.6.3 *Humidity.* No correction for humidity shall be made on wet-flashover values.

4.2.7 Probable Variation. Due to variations in water spray and differences in atmospheric or other uncontrollable conditions, even with properly standardized equipment, a variation of ± 8 percent from the probable true average wet-flashover value may be expected in tests conducted in one laboratory and ± 12 percent in values obtained in tests conducted in different laboratories. Larger variations may be expected on bushings.

4.2.8 Low-Frequency Withstand Voltage Tests. Withstand voltage tests are made to determine that the test specimen is capable of withstanding a specified voltage without disruptive discharge.

4.2.9 Low-Frequency Dry-Withstand Voltage Tests.

4.2.9.1 *Test Voltage and Time.* The test voltage, which is the rated-withstand voltage with appropriate atmospheric corrections applied, shall be held on the specimen for 1 minute without disruptive discharge.

4.2.9.2 *Specimen Mounting.* For low-frequency dry-withstand tests, the specimen shall be mounted in accordance with 3.1 through 3.7.3.

4.2.9.3 *Voltage Application.* Seventy-five (75) percent of the rated-withstand voltage may be applied in one step and gradually raised to the required value in not less than 5 nor more than 30 seconds.

4.2.9.4 *Corrections.* Use corrections in 4.1.4. For insulator types on which disruptive discharge takes the form of a flashover in air, the specified withstand voltage, as given for standard atmospheric conditions, must be corrected for the existing atmospheric conditions at the time of test before applying the test. Such correction* shall be made as follows:

$$V_m = V_s \times \frac{\delta}{K}$$

V_m = Maximum test potential kv
V_s = Specified withstand voltage
δ = Relative air density
K = Humidity correction factor applicable for particular test specimen

For insulator types on which disruptive discharge occurs as a breakdown of the solid or liquid dielectric, no atmospheric corrections shall be applied.

4.2.10 Low-Frequency Wet-Withstand Voltage Tests

4.2.10.1 *Test Voltage and Time.* The test voltage, which is the rated-withstand voltage, with appropriate atmospheric corrections applied, shall be held on the specimen for 10 seconds without disruptive discharge.

4.2.10.2 *Specimen Mounting.* For low-frequency wet-withstand tests, the specimens shall be mounted in accordance with 3.7 through 3.7.3.

4.2.10.3 *Precipitation.* The precipitation shall be applied to a specimen in accordance with 4.2.2 through 4.2.5.2.

4.2.10.4 *Voltage Application.* Seventy-five (75) percent of the rated-withstand voltage may be applied in one step and gradually raised to the required value in not less than 5 nor more than 30 seconds.

4.2.10.5 *Corrections.* Use corrections in 4.2.6, except as follows:

For insulator types on which disruptive discharge takes the form of a flashover in air, the test voltage shall be the rated-withstand voltage corrected for existing relative air density. No correction for humidity shall be made. For insulator types on which the disruptive discharge occurs as a breakdown of the solid or liquid dielectric, no atmospheric corrections shall be applied.

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* The correction given is for suspension, switch and bus, and pin-type insulators. No adjustment for variation from standard atmospheric conditions shall be made for roof and wall bushings.

4.3 Impulse-Flashover Test

4.3.1 General. Impulse-flashover tests are made under dry conditions only.

4.3.2 Impulse-Voltage Wave. All tests shall be made with a 1½ x 40 microsecond wave.

4.3.3 Specimen Mounting. The specimen mounting for impulse-flashover test shall be in accordance with 3.1 through 3.7.3.

4.3.4 Determination of Critical Impulse-Flashover Voltage Value. The critical impulse-flashover voltage may be determined by either of the following methods.

4.3.4.1 *Method 1.* The critical impulse-flashover voltage shall be determined by applying impulses of varying magnitude to the specimen and measuring the crest voltage of the impulse which will cause flashover on approximately 50 percent of the applications. Impulses shall be applied in increasing or decreasing voltage steps, such that at the highest step, flashover occurs on every impulse and at the lowest step no flashover occurs. At least 3 impulses shall be applied at each voltage step and the voltage differential from one step to the next shall not exceed 5 percent of the expected critical impulse-flashover voltage. In cases where the voltage spread from the highest to the lowest step is relatively great, the critical impulse-flashover voltage may be determined by plotting an average curve of crest voltage versus flashover frequency. The crest voltage at the point where the flashover frequency is 50 percent shall be taken as the critical impulse flashover.

4.3.4.2 *Method 2.* The critical impulse-flashover voltage shall be obtained by applying not less than 8 impulses of varying magnitude to the specimen so that flashover occurs on not less than 30 percent and not more than 70 percent of the total impulses applied. The critical impulse-flashover voltage shall be the crest value of the lowest impulse causing flashover. At least 1 full wave shall be greater than 95 percent of the critical impulse-flashover voltage.

4.3.5 Volt-Time Flashover Curves. The complete impulse-flashover characteristics of a specimen tested with the 1½ x 40 microsecond wave may be presented by means of volt-time curves. Data for plotting volt-time curves shall be obtained by increasing the excitation voltage of the impulse generator in percentage steps of the excitation voltage at the approximate critical flashover. The voltage may be measured by means of a parallel-sphere gap or a cathode-ray oscillograph and the time to flashover may be measured by means of a cathode-ray oscillograph. Enough test points shall be determined to define the curve within the required limits. Volt-time curves shall be plotted as a smooth line representing the most probable mean of the data points and terminating at the longest and shortest measured times.

4.3.6 Corrections

4.3.6.1 *Standard Conditions.* The critical impulse-flashover values shall be corrected to the following standard conditions:

Barometer	29.92 in. (760 mm)
Temperature	77 F (25 C)
Vapor Pressure	0.6085 in. (15.45 mm)

4.3.6.2 *Air Density.* The impulse-flashover values shall be corrected to standard air density in accordance with American Standards for Measurement of Test Voltage in Dielectric Tests, ASA C68.1-1942 or latest revision thereof. The relative air density can be obtained by the formulas:

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air density can be obtained by the formulas:

$$\delta = \frac{17.9\, p_b}{459 + t}$$

where p_b is expressed in inches of mercury and t in degrees F

$$\delta = \frac{0.392\, p_b}{273 + t}$$

where p_b is expressed in millimeter of mercury and t in degrees C

δ = Relative air density
t = Room temperature
p_b = Barometric pressure

4.3.6.3 *Humidity.* The critical impulse-flashover value shall be corrected to standard humidity conditions in accordance with tentative curves in Figure 2.*

The vapor pressure shall be determined by the following procedure:

Humidity shall be measured with wet and dry bulb thermometers, the air being circulated past the thermometers at a velocity of 3 meters (9.84 feet) or more per second or by the sling psychrometer. The measurements shall be reduced to vapor pressure with the assistance of the Smithsonian Meteorological Tables or by the following formulas:

$$p_h = p_s - 0.000367\, p_b\, (t - t')\left(1 + \frac{t' - 32}{1571}\right)$$

where p_h and p_s are in inches and t in degrees F

$$p_h = p_s - 0.000660\, p_b\, (t - t')\,(1 + 0.00115\, t')$$

where p_h and p_s are in millimeters and t in degrees C

p_h = Vapor pressure
p_s = Pressure of saturated aqueous vapor at temperature t'
t = Temperature of air
t' = Wet bulb temperature of air
p_b = Barometric pressure

4.3.6.4 *Volt-Time Curves.* The full humidity correction shown on the curves in Figure 2 shall be applied to the critical-flashover value. For volt-time curves the correction shall be made as follows.

4.3.6.4a When the critical-flashover value occurs at more than 10 microseconds, full corrections shall be applied to all values with time lags of 10 microseconds or more. When flashover occurs at less than 10 microseconds, the correction shall be reduced in the direct ratio that the time to flashover bears to 10 microseconds.

4.3.6.4b When the critical-flashover value occurs at less than 10 microseconds, the correction shall be reduced in the direct ratio that the time to flashover bears to the time at the critical flashover.

4.4 Impulse-Withstand Voltage Test

4.4.1 General. Withstand voltages tests are made to determine that the dielectric will be capable of withstanding a specified impulse voltage without disruptive discharge on the test specimen.

4.4.2 Procedure. Withstand voltage tests shall be made with an impulse of that polarity which produces the lower critical-withstand voltage on the test specimen. Three consecutive impulses shall be applied to the test specimen. The crest voltage of each shall be not less than the specified withstand voltage properly corrected.

4.4.3 Corrections. Different types of insulation require different corrections as follows.

4.4.3.1 *Flashover in Air.* For insulator types on which disruptive discharge takes the form of a flashover in air, the specified withstand voltage as given for standard atmospheric conditions, must be corrected for the existing atmospheric conditions at the time of test. This correction shall be made before applying the test by means of the following formula:

$$V_m = V_s \times \frac{\delta}{K}$$

V_m = Maximum test potential kv
V_s = Specified withstand voltage
δ = Relative air density
K = Humidity correction factor applicable for particular test specimen

4.4.3.2 *Breakdown of Solid or Liquid Dielectric.* For insulator types on which disruptive discharge occurs as a breakdown of the solid or liquid dielectric, no atmospheric correction shall be applied.

4.4.4 Acceptance or Rejection. If a disruptive discharge does not occur during any of the three consecutive impulses, the specimen shall be considered as having met the test. If 2 or 3 of the applied impulse waves cause disruptive discharge, the test specimen shall be considered as having failed the test. If only 1 of the three applied impulses causes disruptive discharge, 3 additional impulses shall be applied. If disruptive discharge does not occur on any of these three additional impulses, the specimen shall be considered as having met the test.

4.4.5 Probable Variation. Due to differences in atmospheric and other uncontrollable conditions, even with properly standardized equipment, a variation of ± 5 percent from the probably true average impulse critical-flashover value may be expected in test conducted in one laboratory and ± 8 percent in values obtained in tests conducted in different laboratories. Larger variations may be expected on bushings. In volt-time curves similar variations are to be expected at points near the impulse critical-flashover value with considerably larger variations involved as the time to breakdown decreases.

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* The curves given are for suspension, switch and bus, and pin-type insulators. Curves are not available for bushings and other types.

4.5 Radio-Influence Voltage Test

4.5.1 Specimen Mounting. The insulator shall be mounted in the same manner as described in 3.1 through 3.7.3, except as follows: For specimens having a length in excess of 6 feet, the clearance to grounded objects shall be not less than 3 feet per 100 kv of test voltages with a minimum clearance of 9 feet. All hardware associated with the test circuit shall be relatively free of radio influence at a voltage 10 percent higher than the voltage at which the tests are to be performed. Hardware in contact with the insulator shall be in accordance with the manufacturer's recommendation for operation.

4.5.2 Equipment. The equipment used in making the radio-influence voltage tests shall be in accordance with the recommendations of the Joint Coordination Committee on Radio Reception of EEI, NEMA, and RMA as set forth in EEI Publication G9 (NEMA Publication 107, RMA Engineering Bulletin 32) of February, 1940.

4.5.2.1 *Wave Shape.* A sine wave of acceptable commercial standards shall be applied to the insulator for radio-influence voltage testing. Such a wave shape is defined in American Standards for Measurement of Test Voltage in Dielectric Tests, C68.1-1942 or latest revision thereof.

4.5.2.2 *Supply Voltage Frequency.* The frequency of the supply voltage shall be 60 cycles per second ± 5 percent.

4.5.3 Methods of Making Test

4.5.3.1 *Radio-Influence Voltage.* The specified potential is applied to the specimen and the radio-influence voltage is measured in microvolts at the specified radio frequency.

4.5.3.2 *Radio-Influence Characteristics.* The radio-influence characteristics consist of a number of test points for which both the low-frequency test voltage and the corresponding radio-influence voltage are known.

Increments in voltage in ascending steps may be applied to the test specimen and the corresponding radio-influence voltage noted; but the voltage may be increased in steps in such a way that the radio-influence voltage would be a series of desired values. In the latter case, it is recommended that the series of desired values be 10, 20, 50, 100. 200, 500, etc., microvolts, as these approximately equal the steps of the logarithmic scale. It is considered impractical to read radio-influence test voltages smaller than 10 microvolts.

4.5.4 Atmospheric Conditions. Tests shall be conducted under atmospheric conditions prevailing at the time and place of test, but it is recommended that tests be avoided when the vapor pressure exceeds 0.6 inch of mercury. Since the effect of humidity and air density upon the radio-influence voltage are not definitely known, no correction factors are recommended for either at the present time. However, it is recommended that barometric pressure and dry and wet bulb thermometer readings be recorded so that if suitable correction factors should be determined, they could be applied to previous measurements.

4.5.5 Precautions in Making Radio-Influence Voltage Tests. The following precautions should be observed when making a radio-influence voltage test on an insulator:

(*a*) The insulator should be at approximately the same temperature as the room in which the test is made.

(*b*) The insulator should be clean.

(*c*) The insulator should not be subjected to flashover tests within 2 hours prior to radio-influence voltage test.

(*d*) In some cases it may be found that the radio-influence voltage falls off rapidly after the 60-cycle voltage has been applied for a short time. In such cases it may be desirable to pre-excite the insulator at normal operating voltage for a period not to exceed 5 minutes before proceeding with the tests.

4.6 Corona Test

4.6.1 General. For the purpose of locating the source of radio influence, a corona test may be performed. Its use, however, as a substitute for a radio-influence voltage test, is discouraged as corona within the assembly as a source of radio influence cannot be observed, while, on the contrary, certain visible effects are not a source of radio influence.

4.6.2 Specimen Mounting. When desired, the test shall be performed as follows: The testing arrangement shall be the same as described in 3.1 through 3.7.3. Hardware in contact with the insulator shall be in accordance with the manufacturer's recommendation for operation except as follows: For specimens having a length in excess of 6 feet, the clearance to grounded objects shall be not less than 3 feet per 100 kv of test voltage, with a minimum of 9 feet. The tests shall be made in a thoroughly darkened room.

4.6.3 Testing Equipment Requirements. The entire testing arrangement shall be free from corona at a voltage 10 percent higher than the voltage at which the tests are to be performed.

4.6.4 Procedure. A voltage well above the corona point shall be applied and slowly lowered until all visible brush discharges disappear from the insulator. The point of disappearance shall be the corona voltage. The observer shall have been in the dark for at least 5 minutes before making visual observations.

4.7 Puncture Test

4.7.1 Testing Arrangement. Puncture tests shall be performed on fully assembled insulators only. The specimen shall be inverted and immersed in insulating oil having sufficient dielectric strength to prevent external flashover before puncture occurs. The oil shall be at least 6 inches deep over all parts of the insulator. Voltage shall be applied between the integrally assembled electrode (cap and pin) on all units having these parts therewith.

4.7.2 In the case of pin-type insulators having no conducting electrodes at one or both terminals, electrodes shall be provided as follows: An electrode in the pinhole shall be provided by setting a metallic thimble, with suitable conducting material, such as cement or alloy. The thimble shall be provided with a close-fitting pin for attaching the conductor. The head of the insulator shall be covered with a cap of conducting material approximately ¾ inch larger in radius than the insulator head.

4.7.3 Application of Voltage. Voltage shall be applied between the electrodes described in 4.7.1, above, and it shall be raised at the rate of approximately 10,000 volts every 15 seconds to a value at which puncture occurs. The initial applied voltage may be raised quickly to the rated dry-flashover voltage of the specimen. In case several specimens of the same type are tested, the percent variation of the puncture voltage may be determined in accordance with the following:

Let

$V_1\,V_2\,V_3 \ldots\ V_n =$ individual puncture voltage values

$V =$ average puncture voltage

$$V = \frac{(V_1 + V_2 + V_3 \ldots\ldots + V_n)}{n}$$

Let

$$a_1 = V - V_1 \qquad a_2 = V - V_2$$
$$a_3 = V - V_3 \qquad A_n = V - V_n$$

Consider all these values of "a" as positive, that is, neglect the signs.

Let

$a =$ average variation

$A =$ percent average variation

Then

$$a = \frac{(a_1 + a_2 + a_3 \ldots\ldots + a_n)}{n}$$

$$A = \frac{100\,a}{V}$$

Example:

Five insulators punctured at 150, 135, 145, 138, 142 kv, respectively

$$V = \frac{(150 + 135 + 145 + 138 + 142)}{5} = 142$$

$$a = \frac{(8 + 7 + 3 + 4 + 0)}{5} = 4.4$$

$$A = \frac{(100 \times 4.4)}{142} = 3.09 \text{ percent}$$

5. MECHANICAL TESTS

5.1 Mechanical-Strength Tests

5.1.1 General. Mechanical load shall be applied to the insulator in the manner prescribed in 5.1.2, 5.1.3, 5.1.4, 5.1.5, 5.1.6 and 5.1.7, following, corresponding to the type of insulator involved. The load shall be started at zero and smoothly brought up in a practically stepless variation to the failure point. The load is to be increased rapidly to approximately 75 percent of rated strength of the insulator and at a slower rate from this point to failure. The rate of increase of load from 75 percent of rating to failure is to be given in the following tabulation:

Class of Insulator	Type of Test	Increase in Load Per Minute in Percentage of Rated Strength	
		Minimum	Maximum
Suspension	Tension	15	30
Pin Type	Cantilever	30	60
Switch and Bus	Cantilever	30	60
Switch and Bus	Torsion	30	60
Switch and Bus	Tension	15	30
Switch and Bus	Compression	15	30

5.1.2 **Suspension Insulators.** Tensile and impact-strength tests shall be made as follows.

5.1.2.1 *Tensile Strength.* Mechanical tensile load shall be applied between terminal fittings in line with the axis of the specimen.

5.1.2.2 *Impact Strength.* When this test is required, a testing machine shall be used. The specimen shall be mounted in the test machine under a tension of approximately 2,000 pounds. The bearing point of the pendulum shall be so adjusted that, when released, the copper nose will strike the lowest point of the outer rim of the shell squarely in a direction parallel to the axis of the unit and towards the cap. The insulator shall be struck a blow of the specified severity in inch-pounds by raising the pendulum until its shaft is opposite the corresponding inch-pound mark on the indicating scale. The pendulum shall be released with no imparting acceleration. After receiving the prescribed blow, the unit shall be subjected to momentary flashover.

5.1.3 **Pin-Type Insulators.** A cantilever strength test shall be made as follows.

5.1.3.1 *Cantilever Strength.* Mechanical load shall be applied in line with the side groove of the specimen and normal to the axis of the pinhole. The load at the tie-wire groove may be applied by means of a loop of flexible stranded cable or the equivalent. The mounting pin, connecting hardware, and linkages between the specimen and the testing machine shall be of such design that no appreciable stretch or deflection takes place in them at values up to the failure point of the specimen. Insulators whose design incorporates self-contained metal caps, mounting bases, pins, or conductor clamps, shall be tested with this hardware, using a suitable rigid support.

5.1.4 **Switch and Bus Insulators.** Cantilever-torsional,-tensile- and compression-strength tests shall be made as follows.

5.1.4.1 *Cantilever Strength.* Cantilever-strength tests shall be made with the specimen unit secured to the testing machine by the regular mounting bolts or equivalent. The load shall be applied at right angles to the axis of the insulator unit and at the specified point of application. In testing stacks of 2 or more insulator units, 1 insulator unit may be used. The required lever arms may be obtained by bolting to the specimen to be tested, a bar or pipe of necessary length and stiffness.

5.1.4.2 *Torsional Strength.* Torsional-strength tests shall be made with the specimen secured to the testing machine by the regular mounting bolts or equivalent. The load shall be applied at right angles to the axis of the specimen through a torque member so constructed that the specimen is not subjected to any cantilever stress.

5.1.4.3 *Tensile Strength.* Tensile-strength tests shall be made with the specimen secured to the testing machine by the regular mounting bolts or equivalent. The load shall be applied in line with the axis of the specimen.

5.1.4.4 *Compression Strength.* Compression-strength tests shall be made by applying load in compression in line with the axis of the specimen.

5.1.5 **Guy Insulators.** A tensile-strength test shall be made as follows.

5.1.5.1 *Tensile Strength.* Mechanical load shall be applied in line with the main axis of the specimen using standard guy wire. Each guy-wire loop shall be clamped so as to prevent slipping of the wire, and the clamps shall be so positioned that the distance between the edge of the nearest clamp and the end of the insulator is 1 insulator length. The diameter of the guy wire used should not exceed 75 percent of the diameter of the hole in the insulator.

NOTE: Open-end type and special high-strength insulators should be tested with flexible, stranded, steel cable of the size for which they are designed.

5.1.6 **Spool Insulators.** A transverse-strength test shall be made as follows.

5.1.6.1 *Transverse Strength.* The specimen shall be mounted between close-fitting parallel straps, using a through bolt of the same diameter and characteristics as that for which the spool is designed. The straps and connecting linkage shall be of such materials and proportions that no appreciable stretch or deflection will take place in them at values up to the failure point of the specimen. Mechanical load shall be applied in the plane of the external wire groove. The load shall be applied by means of a loop of flexible, stranded, steel cable clamped so as to prevent slipping. The diameter of the flexible cable should not exceed the radius of the wire grooves.

5.1.7 **Wire Holders.** Tensile- and cantilever-strength tests shall be made as follows.

5.1.7.1 *Tensile Strength.* The screw is to be gripped firmly in the testing machine in such a manner that the mounting surface of the specimen does not touch the support. Load shall be applied in line with the axis of the mounting screw, using a loop of flexible, stranded, steel cable, the diameter of which should not exceed the radius of the wire hole in the insulator. The loop shall be clamped so as to prevent slipping, with the inside edge of the nearest clamp placed 9 inches from the end of the specimen.

5.1.7.2 *Cantilever Strength.* The mounting screw shall be held rigidly in a hole in an angle-plate support by means of a set screw or the equivalent in such a manner that the mounting base of the specimen seats squarely against the face of the plate. Mechanical cantilever load shall be applied in a plane parallel to the mounting surface, passing through the center of the wire hole, using the same flexible loop arrangement described in 5.1.7.1.

5.2 Combined Mechanical- and Electrical-Strength Test

5.2.1 **Suspension Insulators.** Mechanical load shall be applied as described in 5.1.1 and 5.1.2.1. Simultaneously, a low-frequency potential equal to 75 percent of the dry-flashover rating shall be applied to the specimen.

5.3 Time-Loading Test

5.3.1 **Testing Machine.** This test when required shall be performed in a suitable testing machine capable of continuously maintaining mechanical loads. The machine shall be capable of reasonably accurate calibration and of such design that slight distortion or elongation of the specimen will not appreciably change the loading.

5.3.2 **Mounting of the Specimen.** The specimen shall be mounted for this test essentially in accordance with directions given in 5.1.2, 5.1.3, 5.1.4, 5.1.5, 5.1.6, and 5.1.7.

5.3.3 **Application of Load.** The load shall be applied as smoothly and as rapidly as the manipulation of the load-applying devices may reasonably permit and without undue vibrational or shock effects to the specified values, and shall be maintained for the specified period. After the load has been removed, the specimen shall be checked for electrical soundness by being subjected to momentary flashover. Insulators having more than 1 shell shall have each shell checked individually for electrical soundness.

5.4 Porosity Test

5.4.1 **Preparation of Specimen.** Freshly broken fragments of the dielectric body taken from the specimen in question, having clean and apparently unshattered surfaces exposed, shall be used for this test. At least 75 percent of the area of such specimens should be free from glaze or other surface treatment. Fragments approximately ¼ inch in the smallest dimension up to ¾ inch in the largest dimension are recommended.

5.4.2 **Testing Solution.** For the purpose of this test a suitable quantity of prepared testing solution shall be available. A solution consisting of 1 gram of basic fuchsine in 1 liter of 50 percent alcohol is suitable. If denatured alcohol is used, one should be selected which does not react with the dye to cause fading of the color.

5.4.3 **Testing Equipment.** A suitable pressure chamber is required of such dimensions as to accommodate the fragments involved when immersed in the dye solution, with arrangements for obtaining and maintaining the required pressure for the required time.

5.4.4 **Procedure.** The specimens shall be placed in the pressure chamber completely immersed in the testing solution. A pressure of approximately 4000 pounds per square inch shall be applied for approximately 15 hours or an optional test at 10,000 pounds per square inch for 6 hours may be used. Pressure may vary ± 10 percent from the designated value. At the conclusion of the test the specimens shall be removed from the pressure chamber, thoroughly dried, and broken as soon as possible after the release of the pressure.

5.4.5 **Interpretation of Results.** Penetration into small fissures formed in preparing the specimens shall be disregarded. Porosity is indicated by penetration of the dye into the body of the dielectric to an extent visible to the unaided eye.

5.5 Thermal Test

5.5.1 **General.** The thermal test shall consist of alternate immersion in hot and cold water.

5.5.2 **Procedure for Testing Suspension Insulators and Unassembled Shells, 5.5.4, Pin-Type Insulators Having a Flashover Greater than 85,000 Volts and Switch and Bus Insulators, 5.5.5, and One-Piece Pin-Type Insulators Having a Flashover of 85,000 Volts or Less, 5.5.6.1.** The specimen shall first be immersed in a hot-water bath for 10 minutes. It shall then be immediately transferred to a cold-water bath where it shall remain for 10 minutes. The test shall be continued for 10 such complete temperature cycles. The transfer time between successive immersions and between successive cycles shall not exceed 5 seconds except at the end of the fifth cycle. At the end of the fifth and tenth cycles, the specimen shall be checked for electrical soundness by being subjected to momentary flashover.

5.5.3 **Alternative Procedure for Testing One-Piece Pin-Type Insulators Having a Flashover of 85,000 Volts or Less, 5.5.6.2.** The thermal test shall consist of transferring the insulators from a hot-water bath to a cold-water bath and then from a cold to a hot bath. Two water baths, which may be made of planking or metal, are required. If metal baths are employed, they shall be insulated with 1 inch of cork or equivalent material to prevent excessive cooling at the sides. One bath shall be equipped with means for heating the water unless a supply of pre-heated water is used. The heating supply shall be so placed that the water bath will be heated uniformly. No method which applies heat directly to the walls of the bath, such as heating the bath on a hot plate, shall be used, and no heat is to be added during the period of immersion. If ice is used to adjust the temperature of the cold bath, it shall be removed from the bath and the water stirred before immersing the insulators.

The volume of the water in each bath shall be at least 50 times the volume of the insulators immersed. An open rack arranged to keep the units separated from each other and to support them on their sides in a substantially horizontal position shall be provided for immersing the insulators. There should be openings in the base of the rack and in the sides between the slats so as to permit transfer of the insulators without causing excessive agitation at the time of immersion. There shall be a clearance of at least 3 inches between the sides of the rack and the sides of the bath. Standard thermometers, preferably partial-immersion thermometers graduated in degrees F, shall be used to measure the temperature of the baths.

The water shall be stirred and then the temperature of each of the water baths shall be checked for uniformity by noting the temperature at various places in the bath. The insulators shall be immersed to mid-depth of the bath to permit the filling of the pin cavity and the space between petticoats.

5.5.3.1 *Hot to Cold Test.* The insulators shall be placed in the hot-water bath for 10 minutes and then immersed 5 seconds later in the cold-water bath, left therein for 10 minutes and then removed and examined for cracks, chips, and spalls.

5.5.3.2 *Cold to Hot Test.* The same insulators shall then be placed in the cold-water bath for 10 minutes and then immersed 5 seconds later in the hot-water bath, left therein 10 minutes and then removed and examined for cracks, chips, and spalls.

5.5.4 **Temperature of Baths for Suspension Insulators and Unassembled Shells.** For assembled suspension insulators and unassembled shells, the temperature of the hot-water bath shall be approximately 205 F (96 C) and the temperature of the cold-water bath shall be approximately 39 F (4 C).

5.5.5 **Temperature of Baths for Pin-Type Insulators Having a Flashover Greater than 85,000 Volts, and Switch and Bus Insulators.** For one-piece pin-type insulators having a low-frequency dry flashover greater than 85,000 volts, assembled multipart pin-type insulators, and assembled switch and bus insulators, the temperature of the hot-water bath shall be approximately 150 F (66 C) and the temperature of the cold-water bath shall be approximately 39 F (4 C).

5.5.6 **Temperature of Baths for One-Piece Pin-Type Insulators Having a Flashover of 85,000 Volts or Less.** For one-piece pin-type insulators having a low-frequency dry flashover of 85,000 volts or less, there shall be 2 alternative standard tests, 5.5.6.1 and 5.5.6.2, as follows, the choice of which shall be agreed upon between the purchaser and the manufacturer. The procedure described in 5.5.2, shall be used with the temperature limits given in 5.5.6.1, below, and the procedure described in 5.5.3, above, shall be used with the temperature limits given in 5.5.6.2, below.

5.5.6.1 *Temperature of Baths.* The temperature of the hot-water bath shall be approximately 150 F (66 C) and the temperature of the cold-water bath shall be approximately 39 F (4 C). The procedure shall be that covered by 5.5.2.

5.5.6.2 *Temperature of Baths*

5.5.6.2a **Hot to Cold Test.** The temperature of the hot-water bath shall be between 120 and 140 F (49 and 60 C) and the temperature difference between the hot and cold baths at the time of immersion shall be 70 ± 2 F (39 ± 1 C).

5.5.6.2b **Cold to Hot Test.** The temperature of the hot-water bath shall be between 150 and 170 F (66 and 77 C) and the temperature difference between the cold and hot baths at the time of immersion shall be 100 ± 2 F (56 ± 1 C).

5.6 Pinhole Gaging Test

5.6.1 **General.** When the threaded pinholes of pin-type insulators are formed in the dielectric material of the insulator, such pinholes may be checked when required with 1-inch or 1⅜-inch gage.

5.6.2 **Test Procedure.** This test shall be conducted as follows:

(a) Screw the 1-inch or 1⅜-inch gage, as may be required, into the specimen until the gage is tight. Read the distance from the bottom of the pinhole to the point where the gage stops as indicated by the plunger and scale on the gage.

(b) Remove the insulator from the gage, counting number of revolutions of the insulator with respect to the gage required to release it from the pinhole.

6. GALVANIZING TEST

6.1 **Test Procedure.** Hot dip galvanizing on iron and steel fittings associated with high-voltage insulators shall be tested for uniformity of coating by the copper sulphate dip test (Preece test) in accordance with the instructions given in the Standard Method of Test for Uniformity of Coating by the Preece Test (Copper Sulphate Dip) on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A 239-41.

7. ROUTINE TESTS

7.1 **Routine Electrical Tests.** Routine flashover tests on shell and assembled insulator specimens (including bushings) shall be made in accordance with such of the three procedures 7.1.1, 7.1.2, and 7.1.3, as may be mutually agreed upon between purchaser and manufacturer.

7.1.1 **High-Frequency Test.** For this test, the manufacturer, at his option, may use either of the following methods.

7.1.1.1 *Method 1.* The specimens shall be subjected to a damped high-frequency voltage sufficient to cause flashover for from 3 to 5 seconds. The frequency shall be of the order of 200,000 cycles per second in damped trains, the source of energy being a circuit having a frequency of 15 to 100 cycles.

7.1.1.2 *Method 2.* The specimens shall be subjected to a high-frequency discharge from a 60-cycle transformer adjusted for a no-load voltage of not less than 115 percent of the low-frequency dry flashover of the insulator, this test to be continued for a period of from 3 to 5 seconds. The high frequency superimposed upon the low-frequency voltage shall be not less than 100,000 cycles per second.

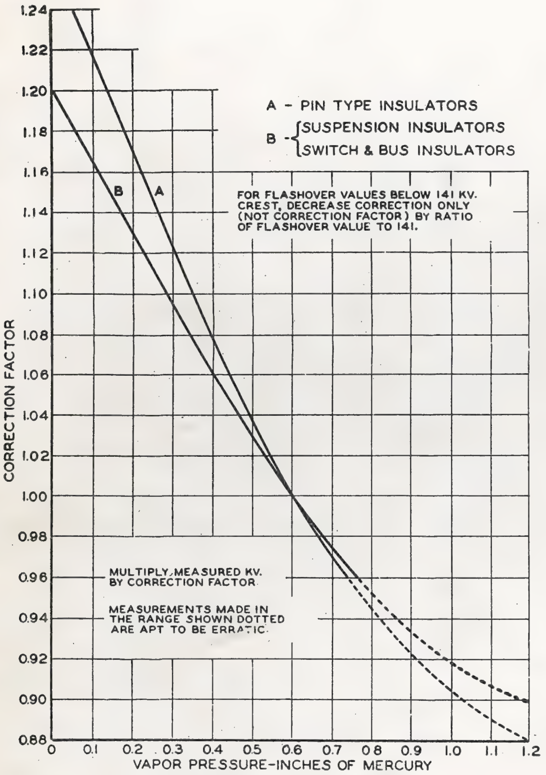
7.1.2 Low-Frequency Test. The specimens shall be subjected to vigorous dry flashover for from 3 to 5 minutes. The voltage control shall be such that a continual flashover occurs and divides uniformly over the insulator under test. To meet this condition it may be necessary to insert additional impedance in the testing circuit.

7.1.3 Overvoltage Test (Assembled Suspension Insulators Only). Each insulator shall be lowered in an upright position into a bath of insulating oil slightly immersing the tips of the lowest parts and the rim to a depth sufficient to prevent flashover. Air shall cover the bottom of the insulator. Not less than 120 percent of the low-frequency dry-flashover voltage of the insulators under test shall then be applied between the two terminals of the insulator for a total of 5 minutes.

7.2 Routine Mechanical Tests

7.2.1 Suspension Insulators. Prior to or simultaneous with the final electrical test, the assembled suspension insulators shall be given a routine mechanical tensile test of 3 seconds duration, applied in line with the axis of the insulator and at a value equal to approximately 40 percent of the rated combined mechanical and electrical strength.

7.2.2 Switch and Bus Insulators. Prior to the final electrical test, the assembled switch and bus insulators shall be given a routine mechanical tensile test of 3 seconds duration, applied in line with the axis of the insulator and at a value of 2,000 pounds or 25 percent of the rated mechanical tensile strength of the insulator, whichever is the smaller.



FOR FLASHOVER VALUES BELOW 141 KV. CREST, DECREASE CORRECTION ONLY (NOT CORRECTION FACTOR) BY RATIO OF FLASHOVER VALUE TO 141.

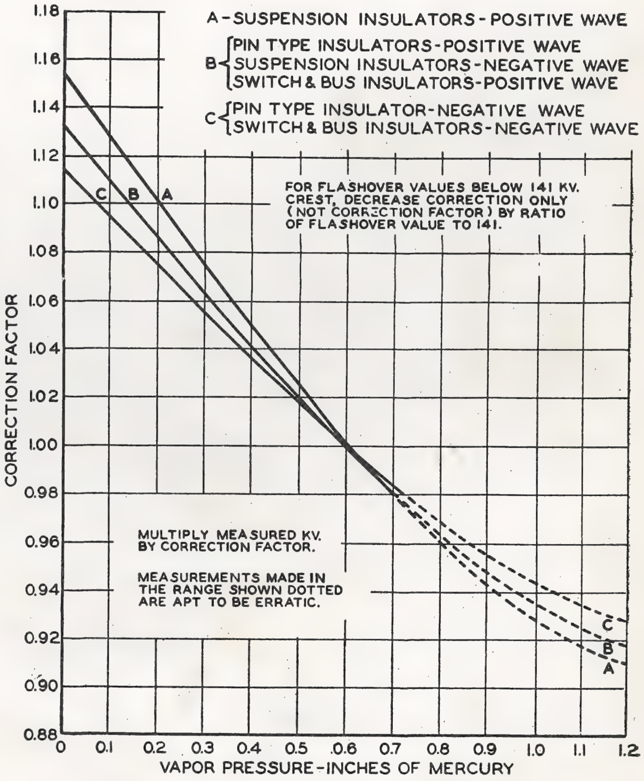
MULTIPLY MEASURED KV. BY CORRECTION FACTOR

MEASUREMENTS MADE IN THE RANGE SHOWN DOTTED ARE APT TO BE ERRATIC.

FIGURE 1

Low-Frequency Humidity Correction Factors

Suspension, Pin-Type, Switch, and Bus Insulators



FOR FLASHOVER VALUES BELOW 141 KV. CREST, DECREASE CORRECTION ONLY (NOT CORRECTION FACTOR) BY RATIO OF FLASHOVER VALUE TO 141.

MULTIPLY MEASURED KV. BY CORRECTION FACTOR.

MEASUREMENTS MADE IN THE RANGE SHOWN DOTTED ARE APT TO BE ERRATIC.

FIGURE 2

Impulse Humidity Correction Factors

Suspension, Pin-Type, Switch, and Bus Insulators

Copies of this American Standard may be obtained from the American Standards Association, Inc., 70 E. 45th St., New York 17, N. Y.

ALUMINUM CABLE, STEEL-REINFORCED BARE

Code Word	ACSR			Copper equivalent, based on equal D.C. resistance. Cop. 97% Alum. 61%	Stranding. Number and diameter of strands—Inches		Diameter—Inches						Ult. Stgth. Lbs.
	Cross Section						Com-plete Cable	Steel Core	Over Armor Rods				
	Aluminum		Total		Aluminum	Steel			Straight	Ta-pered	Preformed		
	Cir. Mils or A.W.G.	Square Inches	Square Inches								Alum. Alloy	Galv. Steel	
Turkey	6	0.0206	0.0240	8	6x0.0661	1x0.0661	0.198	0.0661	0.434		0.440		1170
Thrush	5	0.0260	0.0303	7	6x0.0743	1x0.0743	0.223	0.0743	0.491		0.465		1460
Swan	4	0.0328	0.0383	6	6x0.0834	1x0.0834	0.250	0.0834	0.548		0.542	0.438	1830
Swanate	4	0.0328	0.0411	6	7x0.0772	1x0.1029	0.257	0.1029	0.555		0.549	0.438	2288
Swallow	3	0.0413	0.0482	5	6x0.0937	1x0.0937	0.281	0.0937	0.521		0.573		2250
Sparrow	2	0.0521	0.0608	4	6x0.1052	1x0.1052	0.316	0.1052	0.586		0.608	0.504	2790
Sparate	2	0.0521	0.0653	4	7x0.0974	1x0.1299	0.325	0.1299	0.595		0.617	0.504	3525
Robin	1	0.0657	0.0767	3	6x0.1182	1x0.1182	0.355	0.1182	0.657		0.647	0.543	3480
Raven	1/0	0.0829	0.0967	2	6x0.1327	1x0.1327	0.398	0.1327	0.744		0.742	0.616	4280
Quail	2/0	0.1045	0.1219	1	6x0.1490	1x0.1490	0.447	0.1490	0.745	0.835	0.781	0.665	5345
Pigeon	3/0	0.1318	0.1538	1/0	6x0.1672	1x0.1672	0.502	0.1672	0.836	0.938	0.836	0.774	6675
Penguin	4/0	0.1662	0.1939	2/0	6x0.1878	1x0.1878	0.563	0.1878	0.939	1.051	0.927	0.835	8420
Waxwing	266800	0.2095	0.2211	3/0	18x0.1217	1x0.1217	0.609	0.1217	0.999	1.125	0.973		7100
Owl	266800	0.2095	0.2367	3/0	6x0.2109	7x0.0703	0.633	0.2109		1.179	0.997	0.929	9645
Partridge	266800	0.2095	0.2436	3/0	26x0.1013	7x0.0788	0.642	0.2364		1.188	1.006	0.938	11250
Ostrich	300000	0.2356	0.2740	188700	26x0.1074	7x0.0835	0.680	0.2505		1.258	1.088	1.004	12650
Merlin	336400	0.2642	0.2789	4/0	18x0.1367	1x0.1367	0.684	0.1367	1.046	1.278	1.092		8950
Linnet	336400	0.2642	0.3072	4/0	26x0.1138	7x0.0885	0.721	0.2655		1.349	1.129	1.045	14050
Oriole	336400	0.2642	0.3259	4/0	30x0.1059	7x0.1059	0.741	0.3177		1.369	1.149	1.065	17040
Chickadee	397500	0.3122	0.3295	250000	18x0.1486	1x0.1486	0.743	0.1486	1.075	1.371	1.151		10400
Ibis	397500	0.3122	0.3630	250000	26x0.1236	7x0.0961	0.783	0.2883		1.447	1.283		16190
Lark	397500	0.3122	0.3850	250000	30x0.1151	7x0.1151	0.806	0.3453		1.490	1.306		19980
Pelican	477000	0.3746	0.3954	300000	18x0.1628	1x0.1628	0.814	0.1628	1.180	1.518	1.314		12300
Flicker	477000	0.3746	0.4231	300000	24x0.1410	7x0.0940	0.846	0.2820		1.570	1.346		17200
Hawk	477000	0.3746	0.4356	300000	26x0.1355	7x0.1054	0.858	0.3162		1.602	1.358		19430
Hen	477000	0.3746	0.4620	300000	30x0.1261	7x0.1261	0.883	0.3783		1.649	1.383		23300
Parakeet	556500	0.4371	0.4938	350000	24x0.1523	7x0.1015	0.914	0.3045		1.702	1.414		19850
Dove	556500	0.4371	0.5083	350000	26x0.1463	7x0.1138	0.927	0.341		1.715	1.427		22400
Eagle	556500	0.4371	0.5391	350000	30x0.1362	7x0.1362	0.953	0.409		1.763	1.453		27200
Peacock	605000	0.4752	0.5368	380500	24x0.1588	7x0.1059	0.953	0.318		1.763	1.453		21500
Squab	605000	0.4752	0.5526	380500	26x0.1525	7x0.1186	0.966	0.356		1.798	1.466		24100
Teal	605000	0.4752	0.5835	380500	30x0.1420	19x0.0852	0.994	0.426		1.850	1.614		30000
Rook	636000	0.4995	0.5643	400000	24x0.1628	7x0.1085	0.977	0.326		1.809	1.597		22600
Grosbeak	636000	0.4995	0.5809	400000	26x0.1564	7x0.1216	0.990	0.365		1.846	1.610		25000
Egret	636000	0.4995	0.6134	400000	30x0.1456	19x0.0874	1.019	0.437		1.901	1.639		31500
Flamingo	666600	0.5235	0.5914	419000	24x0.1667	7x0.1111	1.000	0.333		1.856	1.620		23700
Crow	715500	0.5620	0.6348	450000	54x0.1151	7x0.1151	1.036	0.345		1.918	1.656		26300
Starling	715500	0.5620	0.6535	450000	26x0.1659	7x0.1290	1.051	0.387		1.959	1.671		28100
Redwing	715500	0.5620	0.6901	450000	30x0.1544	19x0.0926	1.081	0.463		2.013	1.701		34600
Condor	795000	0.6244	0.7053	500000	54x0.1214	7x0.1214	1.093	0.364		2.025	1.713		28500
Drake	795000	0.6244	0.7261	500000	26x0.1749	7x0.1360	1.108	0.408		2.040	1.728		31200
Mallard	795000	0.6244	0.7668	500000	30x0.1628	19x0.0977	1.140	0.489		2.128	1.760		38400
Crane	874500	0.6868	0.7759	550000	54x0.1273	7x0.1273	1.146	0.382		2.134	1.766		31400
Canary	900000	0.7069	0.7985	566000	54x0.1291	7x0.1291	1.162	0.387		2.150	1.782		32300
Cardinal	954000	0.7493	0.8464	600000	54x0.1329	7x0.1329	1.196	0.399		2.212	1.816		34200
Curlew	1033500	0.8117	0.9169	650000	54x0.1384	7x0.1384	1.246	0.415		2.322	1.976		37100
Finch	1113000	0.8741	0.9849	700000	54x0.1436	19x0.0862	1.293	0.431		2.399	2.023		40200
Pheasant	1272000	0.9990	1.1256	800000	54x0.1535	19x0.0921	1.382	0.461		2.290	2.030		44800
Plover	1431000	1.124	1.2663	900000	54x0.1628	19x0.0977	1.465	0.489					50400
Falcon	1590000	1.249	1.4070	1000000	54x0.1716	19x0.1030	1.545	0.515					56000

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ALUMINUM CABLE, STEEL-REINFORCED BARE (Concluded)

The conductors listed below have a high ratio of mechanical strength to current carrying capacity. They are used largely for overhead ground wires or for special long span construction such as river crossings. Generally speaking, they are of interest where mechanical requirements are of primary importance. They are in every respect standard types of ACSR.

Code Word	ACSR			Copper equivalent, based on equal D.C. resistance. Cop. 97% Alum. 61%	Stranding Number and diameter of strands—Inches		Diameter—Inches					Ult. Stgth. Lbs.
	Cross Section						Com-plete Cable	Steel Core	Over Armor Rods			
	Aluminum		Total									
	Circular Mils	Square Inches	Square Inches		Aluminum	Steel			Straight	Tapered	Pre-formed Alum. Alloy	
Grouse	80000	0.0628	0.0847	50310	8x0.1000	1x0.1670	0.367	0.1670	0.688		0.759	5200
Petrel	101800	0.0800	0.1266	64160	12x0.0921	7x0.0921	0.461	0.2763		0.861	0.795	9860
Minorca	110800	0.0870	0.1378	69700	12x0.0961	7x0.0961	0.481	0.2883		0.893	0.815	10730
Leghorn	134600	0.1057	0.1674	84600	12x0.1059	7x0.1059	0.530	0.3177		0.990	0.864	12920
Guinea	159000	0.1249	0.1977	100000	12x0.1151	7x0.1151	0.576	0.3453		1.078	0.940	15200
Dotterel	176900	0.1389	0.2200	111200	12x0.1214	7x0.1214	0.607	0.3642		1.123	0.971	16440
Dorking	190800	0.1499	0.2373	120000	12x0.1261	7x0.1261	0.631	0.3783		1.177	0.995	17730
Cochin	211300	0.1660	0.2628	132900	12x0.1327	7x0.1327	0.663	0.3981		1.241	1.071	19640
Brahma	203200	0.1596	0.3020	127800	16x0.1127	19x0.0977	0.714	0.4885		1.324	1.122	27500

ALUMINUM CABLE, BARE-CLASSES AA AND A

HARD DRAWN

Code Word	Conductor Size		Copper equivalent, based on equal D.C. resistance. Cop. 97% Alum. 61%	Stranding		Diameter—Inches				Ult. Strength Lbs.
						Over Cable	Over Armor Rods			
	Circular Mils or A.W.G.	Square Inches		Class	No. & Dia. of Wires. Inches		Straight	Tapered	Pre-formed	
Peachbell	6	0.0206	8	A	7x0.0612	0.184			0.426	528
Rose	4	0.0328	6	A	7x0.0772	0.232			0.474	826
Lily	3	0.0413	5	A	7x0.0867	0.260			0.552	1022
Iris	2	0.0521	4	AA, A	7x0.0974	0.292	0.521		0.584	1266
Pansy	1	0.0657	3	AA, A	7x0.1094	0.328			0.620	1537
Poppy	1/0	0.0829	2	AA, A	7x0.1228	0.368	0.688		0.660	1865
Aster	2/0	0.1045	1	AA, A	7x0.1379	0.414	0.770		0.706	2350
Phlox	3/0	0.1318	1/0	AA, A	7x0.1548	0.464	0.774	0.861	0.756	2845
Oxlip	4/0	0.1662	2/0	AA, A	7x0.1739	0.522	0.870	0.970	0.856	3590
Daisy	266800	0.2095	3/0		7x0.1953	0.586	0.976	1.088	0.950	4525
Laurel	266800	0.2095	3/0	A	19x0.1185	0.593		1.088	0.957	4800
Tulip	336400	0.2642	4/0	AA, A	19x0.1331	0.666	1.028	1.219	1.030	5940
Canna	397500	0.3122	250000	AA, A	19x0.1447	0.724	1.056	1.352	1.132	6880
Cosmos	477000	0.3746	300000	AA	19x0.1585	0.793	1.159	1.477	1.293	8090
Syringa	477000	0.3746	300000	A	37x0.1135	0.795		1.477	1.295	8600
Dahlia	556500	0.4371	350000		19x0.1711	0.856		1.600	1.356	9440
Mistletoe	556500	0.4371	350000	AA, A	37x0.1226	0.858		1.600	1.358	9830
Orchid	636000	0.4995	400000	AA, A	37x0.1311	0.918		1.706	1.418	11240
Violet	715500	0.5620	450000	AA	37x0.1391	0.974		1.806	1.474	12640
Nasturtium	715500	0.5620	450000	A	61x0.1083	0.975		1.806	1.475	13150
Arbutus	795000	0.6244	500000	AA	37x0.1466	1.026		1.908	1.646	13770
Lilac	795000	0.6244	500000	A	61x0.1142	1.028		1.908	1.648	14330
Anemone	874500	0.6868	550000	AA	37x0.1538	1.077		2.009	1.697	14830
Crocus	874500	0.6868	550000	A	61x0.1198	1.078		2.009	1.698	15760
Magnolia	954000	0.7493	600000	AA	37x0.1606	1.124		2.084	1.744	16180
Goldenrod	954000	0.7493	600000	A	61x0.1251	1.126		2.084	1.746	16860
Bluebell	1033500	0.8117	650000	AA	37x0.1672	1.170		2.186	1.790	17530
Larkspur	1033500	0.8117	650000	A	61x0.1302	1.172		2.186	1.792	18260
Marigold	1113000	0.8741	700000	AA, A	61x0.1351	1.216		2.260		19660
Narcissus	1272000	0.9990	800000	AA, A	61x0.1444	1.300		2.406		22000
Carnation	1431000	1.1240	900000	AA, A	61x0.1532	1.379		2.287		24300
Coreopsis	1590000	1.2490	1000000	AA	61x0.1615	1.454		2.242		27000
Dogwood	1590000	1.2490	1000000	A	91x0.1322	1.454		2.242		28100

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SOLID ALUMINUM CONDUCTOR WIRE

ROUND WIRE

Conductor Size A. W. G.	Diam. Inches	Circ. Mils	Squ. Inches	D.C. Resistance at 20°C Ohms per 1000 ft. (61%)	Ult. Stgth. Lbs.	Lbs. per 1000 ft.
2	0.2576	66370	0.05213	0.2562	1173	61.08
3	0.2294	52630	0.04134	0.3230	930.1	48.44
4	0.2043	41740	0.03278	0.4073	754.0	38.38
5	0.1819	33100	0.02600	0.5137	597.9	30.46
6	0.1620	26250	0.02062	0.6477	474.2	24.16
7	0.1443	20820	0.01635	0.8166	384.3	19.16
8	0.1285	16510	0.01297	1.030	304.7	15.19
9	0.1144	13090	0.01028	1.299	246.7	12.05
10	0.1019	10380	0.008155	1.638	199.7	9.557
11	0.09074	8234	0.006467	2.065	164.9	7.578
12	0.08081	6530	0.005129	2.604	133.3	6.010
13	0.07196	5178	0.004067	3.284	107.8	4.766
14	0.06408	4107	0.003225	4.140	87.09	3.780
15	0.05707	3257	0.002558	5.220	69.07	2.997
16	0.05082	2583	0.002028	6.582	54.77	2.377
17	0.04526	2048	0.001609	8.302	37.00	1.883
18	0.04030	1624	0.001276	10.47	29.34	1.495
19	0.03589	1288	0.001012	13.20	23.27	1.185
20	0.03196	1022	0.0008023	16.64	18.46	0.9401
21	0.02846	810.1	0.0006363	20.99	14.63	0.7455
22	0.02535	642.5	0.0005046	26.46	11.61	0.5913
23	0.02257	509.5	0.0004001	33.37	9.204	0.4689
24	0.02010	404.0	0.0003173	42.08	7.298	0.3719
25	0.01790	320.4	0.0002517	53.06	5.788	0.2949

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GALVANIZED STEEL STRAND

No. of Wires in Strand	Diameter—Inches Nominal, Strand	 Coated Wires in Strand	 Galv. Steel Preformed Armor Rods	Minimum Breaking Strength of Strand—Lbs. Utilities Grade*	 Common Grade	 Siemens-Martin Grade	 High Strength Grade	 Extra High Strength Grade	Approx. Lbs. 1000 Ft. of Strand
3	¼	0.120	0.428	3,150	1,821	2,979	4,629	6,600	116.7
3	¼	0.120	0.428	4,500					116.7
3	5/16	0.145	0.400	6,500	2,443	4,007	6,214	8,914	170.6
3	⅜	0.165	0.574	8,500	3,171	5,186	8,057	11,528	220.3
7	⅛	0.041			540	910	1,330	1,830	31.8
7	5/32	0.052			870	1,470	2,140	2,940	51.3
7	3/16	0.062			1,150	1,900	2,850	3,990	72.9
7	3/16	0.065		2,400**					80.3
7	7/32	0.072			1,540	2,560	3,850	5,400	98.3
7	¼	0.080	0.447		1,900	3,150	4,750	6,650	121
7	9/32	0.093		4,600**	2,570	4,250	6,400	8,950	164
7	5/16	0.104	0.400		3,200	5.350	8,000	11,200	205
7	5/16	0.109		6,000**					225
7	⅜	0.120	0.580	11,500**	4,250	6,950	10,800	15,400	273
7	7/16	0.145	0.707	18,000**	5,700	9,350	14,500	20,800	399
7	½	0.165	0.791	25,000**	7,400	12,100	18,800	26,900	517
7	9/16	0.188			9,600	15,700	24,500	35,000	671
7	⅝	0.207			11,600	19,100	29,600	42,400	813
19	½	0.100			7,620	12,700	19,100	26,700	504
19	9/16	0.113			9,640	16,100	24,100	33,700	637
19	⅝	0.125			11,000	18,100	28,100	40,200	796
19	¾	0.150			16,000	26,200	40,800	58,300	1,155
19	⅞	0.177			21,900	35,900	55,800	79,700	1,581
19	1	0.200			28,700	47,000	73,200	104,500	2,073
37	1	0.143			28,300	46,200	71,900	102,700	2,057
37	1⅛	0.161			36,000	58,900	91,600	130,800	2,691
37	1¼	0.179			44,600	73,000	113,600	162,200	3,248

* The Utilities Grade is used principally by communication and power and light industries.
** Also called Specification Grade.

COPPER CONDUCTORS—HARD DRAWN

Circular Mils or A.W.G.	Outside Diameter—Inches						Cable Stranding No. & Dia.	Strength—Lbs.		Lbs. per 1000 ft.		
	Over Solid Bare	Over Preformed Armor Rods		Over Cable Bare	Over Preformed Armor Rods			Solid	Cable	Solid	Cable	Cable T.B.W.
		Bronze	C.W.		Bronze	C.W.						
2000000				1.632			127 x .1255		90050		6175	7008
2000000				1.630			91 x .1482		87790		6175	7008
1750000				1.526			127 x .1174		78800		5403	6193
1750000				1.526			91 x .1387		77930		5403	6193
1500000				1.412			91 x .1284		67540		4631	5380
1500000				1.411			61 x .1568		65840		4631	5380
1250000				1.289			91 x .1172		56280		3859	4508
1250000				1.288			61 x .1431		55670		3859	4508
1000000				1.152			61 x .1280		45030		3088	3674
1000000				1.151			37 x .1644		43830		3088	3674
900000				1.094			61 x .1215		40520		2779	3332
900000				1.092			37 x .1560		39510		2779	3332
800000				1.031			61 x .1145		36360		2470	2992
800000				1.029			37 x .1470		35120		2470	2992
750000				.998			61 x .1109		34090		2316	2882
750000				.997			37 x .1424		33400		2316	2882
700000				.964			61 x .1071		31820		2161	2650
700000				.963			37 x .1375		31170		2161	2650
600000				.893			61 x .0992		27530		1853	2235
600000				.891			37 x .1273		27020		1853	2235
500000				.813	1.178	1.178	37 x .1162		22510		1544	1894
500000				.811	1.175	1.175	19 x .1622		21950		1544	1894
450000				.770	1.134	1.134	19 x .1539		19750		1389	1724
400000				.726	1.090	1.090	19 x .1451		17560		1235	1553
350000				.679	1.043	1.043	19 x .1357		15590		1081	1345
350000				.710			12 x .1708		15140		1081	1345
300000				.629	.993	.993	19 x .1257		13510		926.3	1174
300000				.657			12 x .1581		13170		926.3	1174
250000				.574	.898	.898	19 x .1147		11360		771.9	985
250000				.600			12 x .1443		11130		771.9	985
4/0				.528	.852	.852	19 x .1055		9617		653.3	800
4/0				.552			12 x .1328		9483		653.3	800
4/0	.4600			.522	.846	.846	7 x .1739	8143	9154	640.5	653.3	800
3/0	.4096			.492			12 x .1183	6722	7556	507.9	518.1	653
3/0				.464	.788	.788	7 x .1548		7366		518.1	653
2/0	.3648			.414	.738	.738	7 x .1379	5519	5927	402.8	410.9	522
1/0	.3249			.368	.624	.624	7 x .1228	4517	4750	319.5	325.8	424
1	.2893	.493	.493	.328	.584	.584	7 x .1093	3688	3804	253.3	258.4	328
1				.360	.616	.616	3 x .1670		3620		255.9	322
2	.2576	.462	.462	.292	.496	.496	7 x .0974	3003	3045	200.9	204.9	270
2				.320	.576	.576	3 x .1487		2913		202.9	264
3	.2294	.433	.433	.285	.489	.489	3 x .1325	2439	2359	159.3	162.5	206
4	.2043	.408	.408	.254	.457	.458	3 x .1180	1970	1879	126.4	128.9	170
5	.1819			.206			7 x .0688	1591	1542	100.2	102.2	140
6	.1620	.366	.366	.184			7 x .0612	1280	1228	79.5	81.1	115
8	.1285			.146			7 x .0486	826	777	49.5	51.0	78

COPPERWELD SOLID WIRE—BARE

Conductor		Diameter—Inches			Cross Section Area		Breaking Load—Lbs.			Weight Lbs. per 1000 Ft.
Nominal Size A.W.G. or Mil	No. and Size of Wires A.W.G.	Over Conductor	Over Preformed Armor Rods		Cir. Mils	Sq. Inch	Hi-Str.	Hi-Str.	Extra Hi-Str.	
			Bronze	C.W.			Conductivity			
							40%	30%	30%	
080	1	.0800			6400	.005027	770		900	17.76
12	1	.08081			6530	.005129	785			18.12
10	1	.1019			10380	.008155	1130	1231	1460	28.81
104	1	.1040			10820	.008495	1177	1283	1325*	30.01
9	1	.1144			13090	.01028	1368	1491	1790	36.33
128	1	.1280			16380	.01287	1647	1802	2188	45.47
8	1	.1285			16510	.01297	1660	1815	2204	45.81
7	1	.1443			20820	.01635	2011	2207	2681	57.77
6	1	.1620			26250	.02062	2433	2680	3247	72.85
165	1	.1650			27230	.02138	2523	2780	3368	75.55
5	1	.1819			33100	.02600	2938	3250	3913	91.86
4	1	.2043			41740	.03278	3541	3934	4672	115.8
3	1	.2294			52630	.04134	4258	4754	5519	146.1
2	1	.2576			66370	.05213	5056	5682	6412	184.2
1	1	.2893			83690	.06573	5916	6705		232.2
1/0	1	.3249			105500	.08289	6797	7791		292.9
2/0	1	.3648			133100	.1045	8361	9407		369.3
3/0	1	.4096			167800	.1318	10540	11860		465.7
4/0	1	.4600			211600	.1662	13300	14960		587.2

* 40% conductivity.

COPPERWELD STRANDED CABLE—BARE

Conductor		Diameter—Inches			Cross Section Area		Breaking Load—Lbs.			Weight Lbs. per 1000 Ft.
Nominal Size A.W.G. or Mil	No. and Size of Wires A.W.G.	Over Conductor	Over Preformed Armor Rods		Cir. Mils	Sq. Inch	Hi-Str.	Hi-Str.	Extra Hi-Str.	
			Bronze	C.W.			Conductivity			
							40%	30%	30%	
	3x#12	.174	.378	.378	19590	.01539	2236		2565	54.80
	3x#10	.220	.424	.424	31150	.02446	3221	3509	4160	87.13
	3x# 9	.247	.451	.451	39280	.03085	3898	4250	5129	109.9
	3x# 8	.277	.481	.481	49530	.03890	4730	5174	6282	138.5
	3x# 7	.311	.567	.567	62450	.04905	5732	6291	7922	174.7
	3x# 6	.349	.605	.605	78750	.06185	6934	7639	9754	220.3
	3x# 5	.392	.648	.648	99310	.07800	8373	9262	11860	277.8
5/16	7x#10	.306	.562	.562	72680	.05708	7121	7758	9196	203.7
11/32	7x# 9	.343	.599	.599	91650	.07198	8616	9393	11280	256.9
3/8	7x# 8	.385	.642	.642	115600	.09077	10460	11440	13890	323.9
7/16	7x# 7	.433	.757	.757	145700	.1145	12670	13910	16890	408.4
1/2	7x# 6	.486	.810	.810	183800	.1443	15330	16890	20460	515.0
9/16	7x# 5	.546	.870	.870	231700	.1820	18510	20470	24650	649.4
5/8	7x# 4	.613			292200	.2295	22310	24780	29430	818.9
9/16	19x# 9	.572			248800	.1954	23390	25500	30610	700.0
21/32	19x# 8	.642			313700	.2464	28380	31040	37690	882.7
23/32	19x# 7	.721			395500	.3107	34390	37740	45850	1113.
13/16	19x# 6	.810			498800	.3917	41600	45830	55530	1403.
7/8	19x# 5	.910			628900	.4940	50240	55570	66910	1770.

COPPERWELD—COPPER CABLE

Hard Drawn Copper Equivalent Area A.W.G. or M Cir Mils	Type of Conductor	Diameter—Inches			No. and Diam. of EHS 30% Conductivity Copperweld Wires Inches	No. and Diam. of Hard-Drawn Copper Wires Inches	Area Sq. Inches	Breaking Load Lbs.	Weight Lbs. per 1000 Feet
		Over Cable	Over Preformed Armor Rods						
			Bronze	C.W.					
9½	D	.174			2x.08081*	1x.08081	.01539	1743	56.46
8	C	.179	.383	.383	1x.08081	2x.08336	.01604	1362	60.67
8	A	.199	.403	.403	1x.1127	2x.07969	.01995	2233	74.27
8	D	.219	.423	.423	2x.1016	1x.1016	.02431	3256	89.21
7	A	.223	.427	.427	1x.1266	2x.08949	.02516	2754	93.66
7	D	.246			2x.1141	1x.1141	.03066	4022	112.5
6	C	.225			1x.1046*	2x.1046	.02577	2143	97.34
6	A	.230	.434	.434	1x.1068	2x.1068	.02689	2585	101.6
6	D	.276			2x.1281	1x.1281	.03866	4942	141.8
5	A	.258			1x.1200	2x.1200	.03391	3193	128.1
5	D	.310			2x.1438	1x.1438	.04874	6035	178.9
5	P	.326			6x.1087	1x.1087	.06499	9311	234.9
4	A	.290	.494	.494	1x.1347	2x.1347	.04276	3938	161.5
4	D	.348			2x.1615	1x.1615	.06147	7340	225.5
4	N	.328			5x.1092	2x.1092	.06556	8460	240.0
4	P	.366			6x.1221	1x.1221	.08196	11420	296.3
3	A	.326			1x.1513	2x.1513	.05392	4810	203.6
3	J	.311			3x.1036	4x.1036	.05906	5955	221.7
3	K	.336			4x.1120	3x.1120	.06891	7910	255.5
3	N	.368			5x.1226	2x.1226	.08269	10390	302.7
3	P	.411			6x.1371	1x.1371	.1034	13910	373.6
2	F	.308	.564	.564	1x.1026	6x.1026	.05792	4233	222.8
2	G	.327			2x.1089	5x.1089	.06516	5626	247.6
2	A	.366	.622	.622	1x.1699	2x.1699	.06799	5876	256.8
2	J	.349			3x.1164	4x.1164	.07447	7322	279.5
2	K	.377			4x.1257	3x.1257	.08688	9730	322.1
2	N	.413			5x.1377	2x.1377	.1043	12680	381.7
2	P	.462			6x.1540	1x.1540	.1303	16870	471.1
1	F	.346	.602	.602	1x.1153	6x.1153	.07303	5266	280.9
1	G	.367			2x.1222	5x.1222	.08216	6956	312.2
1	J	.392			3x.1307	4x.1307	.09390	9000	352.5
1	K	.423			4x.1412	3x.1412	.1096	11900	406.2
1	N	.464			5x.1546	2x.1546	.1315	15410	481.3
1/0	F	.388	.640	.644	1x.1294	6x.1294	.09207	6536	354.1
1/0	G	.412			2x.1373	5x.1373	.1036	8563	393.6
1/0	J	.440			3x.1467	4x.1467	.1184	10970	444.3
1/0	K	.475			4x.1585	3x.1585	.1381	14490	512.0
2/0	F	.436			1x.1454	6x.1454	.1162	8094	446.8
2/0	G	.463			2x.1542	5x.1542	.1307	10510	496.6
2/0	J	.494			3x.1648	4x.1648	.1493	13430	560.6
2/0	K	.534			4x.1780	3x.1780	.1742	17600	645.9
3/0	F	.490			1x.1632	6x.1632	.1464	9980	563.2
3/0	EK	.509			4x.1018	15x.1018	.1546	12370	593.5
3/0	G	.519			2x.1731	5x.1731	.1647	12860	626.0
3/0	J	.555			3x.1851	4x.1851	.1883	16170	706.7
3/0	E	.545			7x.1091	12x.1091	.1776	16800	672.7
4/0	F	.550			1x.1833	6x.1833	.1847	12290	710.2
4/0	EK	.571			4x.1143	15x.1143	.1949	15370	748.4
4/0	G	.583			2x.1944	5x.1944	.2077	15640	789.4
4/0	E	.613			7x.1225	12x.1225	.2239	20730	848.3
250	EK	.621			4x.1242	15x.1242	.2303	17840	884.2
250	E	.666			7x.1332	12x.1332	.2646	23920	1002
300	EK	.680			4x.1361	15x.1361	.2763	20960	1061
300	E	.729			7x.1459	12x.1459	.3175	27770	1203
350	EK	.735			4x.1470	15x.1470	.3224	23850	1238
350	E	.788			7x.1576	12x.1576	.3704	32420	1403

* High strength copperweld, 40% conductivity.

STANDARD PIPE SIZES

Nominal Diameter Inches	Outside Diameter Inches	Inside Diameter Inches	Thickness Inches	Weight per Foot Lbs.
STANDARD				
⅛	0.405	0.269	0.068	0.24
¼	0.540	0.364	0.088	0.42
⅜	0.675	0.493	0.091	0.57
½	0.840	0.622	0.109	0.85
¾	1.050	0.824	0.113	1.13
1	1.315	1.049	0.133	1.68
1 ¼	1.660	1.380	0.140	2.27
1 ½	1.900	1.610	0.145	2.72
2	2.375	2.067	0.154	3.65
2 ½	2.875	2.469	0.203	5.79
3	3.500	3.068	0.216	7.58
3 ½	4.000	3.548	0.226	9.11
4	4.500	4.026	0.237	10.79
5	5.563	5.047	0.258	14.62
6	6.625	6.065	0.280	18.97
8	8.625	8.071	0.277	24.70
8	8.625	7.981	0.322	28.55
10	10.750	10.192	0.279	31.20
10	10.750	10.136	0.307	34.24
10	10.750	10.020	0.365	40.48
12	12.750	12.090	0.330	43.77
12	12.750	12.000	0.375	49.56
EXTRA STRONG				
⅛	0.405	0.215	0.095	0.31
¼	0.540	0.302	0.119	0.54
⅜	0.675	0.423	0.126	0.74
½	0.840	0.546	0.147	1.09
¾	1.050	0.742	0.154	1.47
1	1.315	0.957	0.179	2.17
1 ¼	1.660	1.278	0.191	3.00
1 ½	1.900	1.500	0.200	3.63
2	2.375	1.939	0.218	5.02
2 ½	2.875	2.323	0.276	7.66
3	3.500	2.900	0.300	10.25
3 ½	4.000	3.364	0.318	12.51
4	4.500	3.826	0.337	14.98
5	5.563	4.813	0.375	20.78
6	6.625	5.761	0.432	28.57
8	8.625	7.625	0.500	43.39
10	10.750	9.750	0.500	54.74
12	12.750	11.750	0.500	65.42
DOUBLE—EXTRA STRONG				
½	0.840	0.252	0.294	1.71
¾	1.050	0.434	0.308	2.44
1	1.315	0.599	0.358	3.66
1 ¼	1.660	0.896	0.382	5.21
1 ½	1.900	1.100	0.400	6.41
2	2.375	1.503	0.436	9.03
2 ½	2.875	1.771	0.552	13.70
3	3.500	2.300	0.600	18.58
3 ½	4.000	2.728	0.636	22.85
4	4.500	3.152	0.674	27.54
5	5.563	4.063	0.750	38.55
6	6.625	4.897	0.864	53.16
8	8.625	6.875	0.875	72.42

Pipe 14″ and larger is sold by actual O.S. diameter and thickness.
Sizes 14″, 15″ and 16″ are available regularly in thicknesses varying by 1/16″ from ¼″ to 1″ inclusive.

UNIFIED AND AMERICAN SCREW THREADS

UNC AND NC THREAD SERIES (AMERICAN STANDARD B1.1-1949)

Designation			External Thread Limits of Size (Inches)										Section at Minor Diameter External Threads Sq. In.	Stress Area External Threads Sq. In.	Internal Thread Limits of Size (Inches)						
Size	Threads per Inch	Thread Symbol	Allowance	Major Diameter					Pitch Diameter†			Minor Dia. (Max.)			Minor Diameter			Pitch Diameter†			Major Dia. Min.
				Limits			Tolerance		Limits		Tolerance				Limits		Tolerance	Limits		Tolerance	
				Max.*	Min.[1]	Min.[2]	1	2	Max.*	Min.					Min.	Max.		Min.	Max.		
1(.073)	64	NC-2A	0.0006	0.0724	0.0686	—	0.0038	—	0.0623	0.0603	0.0020	0.0532	0.0022	0.0026	0.0561	0.0623	0.0062	0.0629	0.0655	0.0026	0.0730
2(.086)	56	NC-2A	0.0006	0.0854	0.0813	—	0.0041	—	0.0738	0.0717	0.0021	0.0635	0.0031	0.0036	0.0667	0.0737	0.0070	0.0744	0.0772	0.0028	0.0860
3(.099)	48	NC-2A	0.0007	0.0983	0.0938	—	0.0045	—	0.0848	0.0825	0.0023	0.0727	0.0041	0.0048	0.0764	0.0845	0.0081	0.0855	0.0885	0.0030	0.0990
4(.112)	40	NC-2A	0.0008	0.1112	0.1061	—	0.0051	—	0.0950	0.0925	0.0025	0.0805	0.0050	0.0060	0.0849	0.0939	0.0090	0.0958	0.0991	0.0033	0.1120
5(.125)	40	NC-2A	0.0008	0.1242	0.1191	—	0.0051	—	0.1080	0.1054	0.0026	0.0935	0.0067	0.0079	0.0979	0.1062	0.0083	0.1088	0.1121	0.0033	0.1250
6(.138)	32	NC-2A	0.0008	0.1372	0.1312	—	0.0060	—	0.1169	0.1141	0.0028	0.0989	0.0075	0.0090	0.1042	0.1140	0.0098	0.1177	0.1214	0.0037	0.1380
8(.164)	32	NC-2A	0.0009	0.1631	0.1571	—	0.0060	—	0.1428	0.1399	0.0029	0.1248	0.0120	0.0139	0.1302	0.1389	0.0087	0.1437	0.1475	0.0038	0.1640
10(.190)	24	NC-2A	0.0010	0.1890	0.1818	—	0.0072	—	0.1619	0.1586	0.0033	0.1379	0.0145	0.0174	0.1449	0.1555	0.0106	0.1629	0.1672	0.0043	0.1900
12(.216)	24	NC-2A	0.0010	0.2150	0.2078	—	0.0072	—	0.1879	0.1845	0.0034	0.1639	0.0206	0.0240	0.1709	0.1807	0.0098	0.1889	0.1933	0.0044	0.2160
¼	20	UNC-2A	0.0011	0.2489	0.2408	0.2367	0.0081	0.0122	0.2164	0.2127	0.0037	0.1876	0.0269	0.0317	0.1959	0.2067	0.0108	0.2175	0.2223	0.0048	0.2500
5/16	18	UNC-2A	0.0012	0.3113	0.3026	0.2982	0.0087	0.0131	0.2752	0.2712	0.0040	0.2431	0.0454	0.0522	0.2524	0.2630	0.0106	0.2764	0.2817	0.0053	0.3125
3/8	16	UNC-2A	0.0013	0.3737	0.3643	0.3595	0.0094	0.0142	0.3331	0.3287	0.0044	0.2970	0.0678	0.0773	0.3073	0.3182	0.0109	0.3344	0.3401	0.0057	0.3750
7/16	14	UNC-2A	0.0014	0.4361	0.4258	0.4206	0.0103	0.0155	0.3897	0.3850	0.0047	0.3485	0.0933	0.1060	0.3602	0.3717	0.0115	0.3911	0.3972	0.0061	0.4375
½	12	UNC-2A	0.0015	0.4985	0.4871	0.4813	0.0114	0.0172	0.4444	0.4393	0.0051	0.3963	0.1205	0.1374	0.4098	0.4223	0.0125	0.4459	0.4525	0.0066	0.5000
½	13	NC-2A	0.0015	0.4985	0.4876	0.4822	0.0109	0.0163	0.4485	0.4435	0.0050	0.4041	0.1257	0.1416	0.4167	0.4284	0.0117	0.4500	0.4565	0.0065	0.5000
9/16	12	UNC-2A	0.0016	0.5609	0.5495	0.5437	0.0114	0.0172	0.5068	0.5016	0.0052	0.4587	0.1620	0.1816	0.4723	0.4843	0.0120	0.5084	0.5152	0.0068	0.5625
5/8	11	UNC-2A	0.0016	0.6234	0.6113	0.6052	0.0121	0.0182	0.5644	0.5589	0.0055	0.5119	0.2018	0.2256	0.5266	0.5391	0.0125	0.5660	0.5732	0.0072	0.6250
¾	10	UNC-2A	0.0018	0.7482	0.7353	0.7288	0.0129	0.0194	0.6832	0.6773	0.0059	0.6255	0.3020	0.3340	0.6417	0.6545	0.0128	0.6850	0.6927	0.0077	0.7500
7/8	9	UNC-2A	0.0019	0.8731	0.8592	0.8523	0.0139	0.0208	0.8009	0.7946	0.0063	0.7368	0.4193	0.4612	0.7547	0.7681	0.0134	0.8028	0.8110	0.0082	0.8750
1	8	UNC-2A	0.0020	0.9980	0.9830	0.9755	0.0150	0.0225	0.9168	0.9100	0.0068	0.8446	0.5510	0.6051	0.8647	0.8797	0.0150	0.9188	0.9276	0.0088	1.0000
1 1/8	7	UNC-2A	0.0022	1.1228	1.1064	1.0982	0.0164	0.0246	1.0300	1.0228	0.0072	0.9475	0.6931	0.7627	0.9704	0.9875	0.0171	1.0322	1.0416	0.0094	1.1250
1 ¼	7	UNC-2A	0.0022	1.2478	1.2314	1.2232	0.0164	0.0246	1.1550	1.1476	0.0074	1.0725	0.8898	0.9684	1.0954	1.1125	0.0171	1.1572	1.1668	0.0096	1.2500
1 3/8	6	UNC-2A	0.0024	1.3726	1.3544	1.3453	0.0182	0.0273	1.2643	1.2563	0.0080	1.1681	1.0541	1.1538	1.1946	1.2146	0.0200	1.2667	1.2771	0.0104	1.3750
1 ½	6	UNC-2A	0.0024	1.4976	1.4794	1.4703	0.0182	0.0273	1.3893	1.3812	0.0081	1.2931	1.2938	1.4041	1.3196	1.3396	0.0200	1.3917	1.4022	0.0105	1.5000
1 ¾	5	UNC-2A	0.0027	1.7473	1.7268	1.7165	0.0205	0.0308	1.6174	1.6085	0.0089	1.5019	1.7441	1.8983	1.5335	1.5575	0.0240	1.6201	1.6317	0.0116	1.7500
2	4½	UNC-2A	0.0029	1.9971	1.9751	1.9641	0.0220	0.0330	1.8528	1.8433	0.0095	1.7245	2.3001	2.4971	1.7594	1.7861	0.0267	1.8557	1.8681	0.0124	2.0000
2 ¼	4½	UNC-2A	0.0029	2.2471	2.2251	2.2141	0.0220	0.0330	2.1028	2.0931	0.0097	1.9745	3.0212	3.2464	2.0094	2.0361	0.0267	2.1057	2.1183	0.0126	2.2500
2 ½	4	UNC-2A	0.0031	2.4969	2.4731	2.4612	0.0238	0.0357	2.3345	2.3241	0.0104	2.1902	3.7161	3.9976	2.2294	2.2594	0.0300	2.3376	2.3511	0.0135	2.5000
2 ¾	4	UNC-2A	0.0032	2.7468	2.7230	2.7111	0.0238	0.0357	2.5844	2.5739	0.0105	2.4401	4.6194	4.9326	2.4794	2.5094	0.0300	2.5876	2.6013	0.0137	2.7500
3	4	UNC-2A	0.0032	2.9968	2.9730	2.9611	0.0238	0.0357	2.8344	2.8237	0.0107	2.6901	5.6209	5.9659	2.7294	2.7594	0.0300	2.8376	2.8515	0.0139	3.0000
3 ¼	4	UNC-2A	0.0033	3.2467	3.2229	3.2110	0.0238	0.0357	3.0843	3.0734	0.0109	2.9400	6.7205	7.0992	2.9794	3.0094	0.0300	3.0876	3.1017	0.0141	3.2500
3 ½	4	UNC-2A	0.0033	3.4967	3.4729	3.4610	0.0238	0.0357	3.3343	3.3233	0.0110	3.1900	7.9183	8.3268	3.2294	3.2594	0.0300	3.3376	3.3519	0.0143	3.5000
3 ¾	4	UNC-2A	0.0034	3.7466	3.7228	3.7109	0.0238	0.0357	3.5842	3.5730	0.0112	3.4399	9.2143	9.6546	3.4794	3.5094	0.0300	3.5876	3.6021	0.0145	3.7500
4	4	UNC-2A	0.0034	3.9966	3.9728	3.9609	0.0238	0.0357	3.8342	3.8229	0.0113	3.6899	10.6084	11.0805	3.7294	3.7594	0.0300	3.8376	3.8523	0.0147	4.0000

† British Effective Diameter.

* Maximum limits are increased by the amount of the allowance for threads which are electroplated or have coatings of similar thicknesses.

[1] For semi-finished and finished screws and bolts, threaded portion only.

[2] For unfinished hot rolled material threaded portion only.

WEIGHTS OF STEEL BARS

Size Inches	Lbs. per Ft.			Size Inches	Lbs. per Ft.			Size Inches	Lbs. per Ft.		
	Round	Square	Hexagon		Round	Square	Hexagon		Round	Square	Hexagon
1/16	.010			19/32	.941	1.20		2	10.68	13.60	11.78
5/64	.016			39/64	.992			2 1/16	11.36	14.46	12.53
3/32	.023			5/8	1.04	1.33	1.15	2 1/8	12.06	15.35	13.30
7/64	.032			41/64	1.10			2 3/16	12.78	16.27	14.09
1/8	.042	.053	.046	21/32	1.15			2 1/4	13.52	17.21	14.91
9/64	.053			11/16	1.26	1.61	1.39	2 5/16	14.28	18.18	15.75
5/32	.065	.083	.072	23/32	1.38			2 3/8	15.06	19.18	16.61
11/64	.079			47/64	1.44			2 7/16	15.87	20.20	17.49
3/16	.094	.120	.104	3/4	1.50	1.91	1.66	2 1/2	16.69	21.25	18.40
13/64	.110			49/64	1.57			2 9/16	17.53	22.33	19.34
7/32	.128	.163	.141	25/32	1.63			2 5/8	18.40	23.43	20.29
15/64	.147			13/16	1.76	2.24	1.94	2 11/16	19.29		
1/4	.167	.213	.184	27/32	1.90			2 3/4	20.19	25.71	22.27
17/64	.188			7/8	2.04	2.60	2.25	2 13/16	21.12		
9/32	.211	.269	.233	29/32	2.19			2 7/8	22.07	28.10	24.34
19/64	.235			15/16	2.35	2.99	2.59	2 15/16	23.04		
5/16	.261	.332	.288	31/32	2.51			3	24.03	30.60	26.50
21/64	.288			1	2.67	3.40	2.94	3 1/16	25.05		
11/32	.316	.402	.348	1 1/32	2.84			3 1/8	26.08	33.20	28.76
23/64	.345			1 1/16	3.01	3.84	3.32	3 3/16	27.13		
3/8	.376	.478	.414	1 1/8	3.38	4.30	3.73	3 1/4	28.21	35.91	31.10
25/64	.408			1 3/16	3.77	4.80	4.15	3 5/16	29.30		
13/32	.441			1 1/4	4.17	5.31	4.60	3 3/8	30.42	38.73	33.54
27/64	.475			1 5/16	4.60	5.86	5.07	3 7/16	31.55		
7/16	.511	.651	.564	1 3/8	5.05	6.43	5.57	3 1/2	32.71	41.65	36.07
29/64	.548			1 7/16	5.52	7.03	6.09	3 9/16	33.89		
15/32	.587			1 1/2	6.01	7.65	6.63	3 5/8	35.09		
31/64	.627			1 9/16	6.52	8.30	7.19	3 11/16	36.31		
1/2	.668	.850	.736	1 5/8	7.05	8.98	7.78	3 3/4	37.55	47.81	41.41
33/64	.710			1 11/16	7.60	9.68	8.39	3 13/16	38.81		
17/32	.754			1 3/4	8.18	10.41	9.02	3 7/8	40.10		
35/64	.799			1 13/16	8.77	11.17	9.67	3 15/16	41.40		
9/16	.845	1.08	.932	1 7/8	9.39	11.95	10.35	4	42.73	54.40	47.11
37/64	.893			1 15/16	10.02	12.76	11.05				

COEFFICIENTS OF LINEAR EXPANSION
RANGE 0-100°C AND 32-212°F

Material	Expansion per Degree (x 10-6)		Material	Expansion per Degree (x 10-6)		Material	Expansion per Degree (x 10-6)	
	C	F		C	F		C	F
Aluminum—Commercial	24.0	13.3	Duralumin—Cold Rolled	23.7	13.2	Nickel	12.6	7.0
Aluminum—Wrought	23.1	12.8	Glass—Flint	7.9	4.4	Nickel Steel (10% Ni)	13.0	7.2
Brass—Cast	18.8	10.4	Iron—Cast	10.6	5.9	Porcelain	4.1	2.3
Bronze	18.1	10.1	Iron—Malleable	12.0	6.6	Solder	25.1	13.9
Cement	12.0	6.7	Iron—Wire	12.4	6.9	Stainless Steel—Annealed	10.3	5.7
Cement—Portland	10.7	5.9	Iron—Wrought	12.0	6.7	Carbon Steel—Annealed	10.5	5.7
Concrete	14.3	7.9	Lead	28.6	15.9	Tin	26.9	15.0
Copper	16.8	9.3	Monel Metal—Average	14.0	7.8	Zinc—Rolled	31.1	17.3

For square surface expansion, multiply linear expansion by 2; for cubical expansion multiply linear expansion by 3.

WEIGHTS OF MATERIALS

MATERIALS	Pounds per Cubic Foot	Sp. Gr. (Water = 1)
Platinum	1338.48	21.45
Gold	1206.09	19.32
Tungsten	1204.32	19.3
Mercury, Fluid	845.27	13.546
Lead, Wire	704.50—707.62	11.29—11.34
Silver	655	10.5
Copper, Cast	555.98	8.91
Copper	556.61	8.92
German Silver	527.28	8.45
Nickel, Cast	555.58	8.9
Phosphor Bronze	555.98	8.91
Bronze	544	8.73
Molybdenum	636.48	10.2
Brass, Wire	524.16	8.4
Brass, Cast	505	8.10
Steel	489.6	7.8
Iron, Wrought	486.93	7.8
Iron, Cast	443.21	7.1
Tin	454.27	7.28
Zinc, Sheet	445.54	7.14
Antimony	415.94	6.62
Aluminum, Wrought	169.17	2.71

MATERIALS	Pounds per Cubic Foot	Sp. Gr. (Water = 1)
Aluminum, Cast	160	2.56
Granite	156—187	2.5—3
Glass	149—187	2.4—3
Porcelain	149.13	2.39
Sandstone	143.58	2.3
Sulphuric Acid (Conc.)	114.9	1.84
Ebonite	71.71	1.15
Nitric Acid	76.2	1.22
Asbestos Board	74.91	1.2
Pure Water	62.425	1.000
Oil, Linseed	58.31	.935
Oil, Turpentine	54.3	.87
Petroleum	54.9	.88
Naphtha	53.1	.85
Benzine	53.1	.85
Oak	49.94	.80
Paper	43—68	.7—1.1
Ether, Sulphuric	44.9	.713
Walnut	43.69	.7
White Pine (Seas.)	31.21	.5
Cork	10.15	.16—.24

CONVERSION FACTORS

Multiply	by	to Obtain
Acres	43560	Square Feet
Acres	4047	Square Meters
Atmospheres	29.92	Inches of Mercury
Atmospheres	33.90	Feet of Water
Atmospheres	14.70	Pounds per Sq. Inch
British Thermal Units	777.5	Foot-Pounds
British Thermal Units	3.927×10^{-4}	Horsepower-Hours
British Thermal Units	2.928×10^{-4}	Kilowatt-Hours
Centimeters	0.3937	Inches
Centimeters	0.01	Meters
Centimeters	10	Millimeters
Circular Mils	5.067×10^{-4}	Square Millimeters
Circular Mils	7.854×10^{-7}	Square Inches
Circular Mils	0.7854	Square Mils
Cubic Centimeters	3.531×10^{-5}	Cubic Feet
Cubic Centimeters	6.102×10^{-2}	Cubic Inches
Cubic Centimeters	10^{-6}	Cubic Meters
Cubic Centimeters	10^{-3}	Liters
Cubic Feet	2.832×10^{-4}	Cubic Centimeters
Cubic Feet	1728	Cubic Inches
Degrees (Angle)	60	Minutes
Degrees (Angle)	0.01745	Radians
Degrees (Angle)	3600	Seconds
Farads	10^{6}	Microfarads
Fathoms	6	Feet
Gallons, U. S.	0.1337	Cubic Feet
Gallons, Imperial	0.1605	Cubic Feet
Gallons, U. S.	231	Cubic Inches
Gallons, Imperial	277.274	Cubic Inches
Grains (Troy) Etc.	0.06480	Grams
Grams	0.03527	Ounces
Horsepower	33000	Foot-lbs. per Min.
Horsepower	745.7	Watts
Inches	2.540	Centimeters
Kilograms	2.205	Pounds
Kilometers	0.6214	Miles
Kilowatts	1.341	Horsepower
Kilowatt Hours	3415	British Thermal Units
Knots	1.152	Miles

Multiply	by	to Obtain
Liters	61.02	Cubic Inches
Megohms	10^{6}	Ohms
Meters	1.094	Yards
Microhms	10^{-6}	Ohms
Miles	1.609	Kilometers
Miles per Hour	1.467	Feet per Second
Mils	10^{-3}	Inches
Ounces	16	Drams
Ounces	28.35	Grams
Ounces (Fluid)	1.805	Cubic Inches
Pounds of Water	27.68	Cubic Inches
Pounds of Water	0.1198	U. S. Gallons
Pounds of Water	0.10	Imperial Gallons
Radians	57.30	Degrees
Reams	500	Sheets
Rods	16.5	Feet
Square Centimeters	0.1550	Square Inches
Square Feet	2.296×10^{-5}	Acres
Square Meters	2.471×10^{-4}	Acres
Temp. (Degs. Cent.) +273	1	Abs. Temp. (Degs. Cent.)
Temp. (Degs. Fahr.) +460	1	Abs. Temp. (Degs. Fahr.)
Temp. (Degs. Fahr.) —32	5/9	Temp. (Degs. Cent.)
Watts	0.05692	B. T. Units per Min.
Watts	0.7376	Foot-lbs. per Sec.
Watt-hours	3.415	British Thermal Units
Weeks	168	Hours
Weeks	10080	Minutes
Weeks	604800	Seconds
Years (Common)	365	Days
Years (Common)	8760	Hours
Years (Leap)	366	Days
Years (Leap)	8784	Hours

TABLE OF MULTIPLES

1 Circular Mil = .7854 Square Mil.
1 Square Mil. = 1.2732 Circular Mils.
Circumference of Circle = Diameter × 3.1416.
Area of Circle = Diameter Squared × .7854.
Diameter of Circle = Circumference ÷ 3.1416
Diameter of Circle = $\sqrt{\text{Area} \div .7854}$.

Diameter of Circle × .8862 = Side of Square of Equal Area.
Area of Ellipse = Product of Two Diameters × .7854.
Surface of a Sphere = Diameter Squared × 3.1416.
Volume of a Sphere = Diameter Cubed × .5236.
Volume of a Cone (Round, Square, Triangular) = Area of Base × ⅓ Altitude.

AREAS AND CIRCUMFERENCES OF CIRCLES

Dia. Inches	Circum-ference Inches	Area Square-Inches	Dia. Inches	Circum-ference Inches	Area Square-Inches	Dia. Inches	Circum-ference Inches	Area Square-Inches	Dia. Inches	Circum-ference Inches	Area Square-Inches
1/64	.049087	.00019	1 3/16	3.73064	1.1075	3 7/16	10.7992	9.2806	5 11/16	17.8678	25.406
1/32	.098175	.00077	1/4	3.92699	1.2272	1/2	10.9956	9.6211	3/4	18.0642	25.967
3/64	.147262	.00173	5/16	4.12334	1.3530	9/16	11.1919	9.9678	13/16	18.2605	26.535
1/16	.196350	.00307	3/8	4.31969	1.4849	5/8	11.3883	10.321	7/8	18.4569	27.109
3/32	.294524	.00690	7/16	4.51604	1.6230	11/16	11.5846	10.680	15/16	18.6532	27.688
1/8	.392699	.01227	1/2	4.71239	1.7671	3/4	11.7810	11.045	6.	18.8496	28.274
5/32	.490874	.01917	9/16	4.90874	1.9175	13/16	11.9773	11.416	1/8	19.2423	29.465
3/16	.589049	.02761	5/8	5.10509	2.0739	7/8	12.1737	11.793	1/4	19.6350	30.680
7/32	.687223	.03758	11/16	5.30144	2.2365	15/16	12.3700	12.177	3/8	20.0277	31.919
1/4	.785398	.04909	3/4	5.49779	2.4053	4.	12.5664	12.566	1/2	20.4204	33.183
9/32	.883573	.06213	13/16	5.69414	2.5802	1/16	12.7627	12.962	5/8	20.8131	34.472
5/16	.981748	.07670	7/8	5.89049	2.7612	1/8	12.9591	13.364	3/4	21.2058	35.785
11/32	1.07992	.09281	15/16	6.08684	2.9483	3/16	13.1554	13.772	7/8	21.5984	37.122
3/8	1.17810	.11045	2.	6.28319	3.1416	1/4	13.3518	14.186	7.	21.9911	38.485
13/32	1.27627	.12962	1/16	6.47953	3.3410	5/16	13.5481	14.607	1/8	22.3838	39.871
7/16	1.37445	.15033	1/8	6.67588	3.5466	3/8	13.7445	15.033	1/4	22.7765	41.282
15/32	1.47262	.17257	3/16	6.87223	3.7583	7/16	13.9408	15.466	3/8	23.1692	42.718
1/2	1.57080	.19635	1/4	7.06858	3.9761	1/2	14.1372	15.904	1/2	23.5619	44.179
17/32	1.66897	.22166	5/16	7.26493	4.2000	9/16	14.3335	16.349	5/8	23.9546	45.664
9/16	1.76715	.24850	3/8	7.46128	4.4301	5/8	14.5299	16.800	3/4	24.3473	47.173
19/32	1.86532	.27688	7/16	7.65763	4.6664	11/16	14.7262	17.257	7/8	24.7400	48.707
5/8	1.96350	.30680	1/2	7.85398	4.9087	3/4	14.9226	17.721	8.	25.1327	50.265
21/32	2.06167	.33824	9/16	8.05033	5.1572	13/16	15.1189	18.190	1/8	25.5254	51.849
11/16	2.15984	.37122	5/8	8.24668	5.4119	7/8	15.3153	18.665	1/4	25.9181	53.456
23/32	2.25802	.40574	11/16	8.44303	5.6727	15/16	15.5116	19.147	3/8	26.3108	55.088
3/4	2.35619	.44179	3/4	8.63938	5.9396	5.	15.7080	19.635	1/2	26.7035	56.745
25/32	2.45437	.47937	13/16	8.83573	6.2126	1/16	15.9043	20.129	5/8	27.0962	58.426
13/16	2.55254	.51849	7/8	9.03208	6.4918	1/8	16.1007	20.629	3/4	27.4889	60.132
27/32	2.65072	.55914	15/16	9.22843	6.7771	3/16	16.2970	21.135	7/8	27.8816	61.862
7/8	2.74889	.60132	3.	9.42478	7.0686	1/4	16.4934	21.648	9.	28.2743	63.617
29/32	2.84707	.64504	1/16	9.62113	7.3662	5/16	16.6897	22.166	1/8	28.6670	65.397
15/16	2.94524	.69029	1/8	9.81748	7.6699	3/8	16.8861	22.691	1/4	29.0597	67.201
31/32	3.04342	.73708	3/16	10.0138	7.9798	7/16	17.0824	23.221	3/8	29.4524	69.029
1.	3.14159	.78540	1/4	10.2102	8.2958	1/2	17.2788	23.758	1/2	29.8451	70.882
1/16	3.33794	.88664	5/16	10.4065	8.6179	9/16	17.4751	24.301	5/8	30.2378	72.760
1/8	3.53429	.99402	3/8	10.6029	8.9462	5/8	17.6715	24.850	3/4	30.6305	74.662

MEASURES AND WEIGHTS

(Based on National Bureau of Standards)

Linear Measure

1 inch = 1000 mils
1 hand = 4 inches
1 foot = 12 inches
1 yard = 3 feet
1 fathom = 6 feet
1 rod = 5 1/2 yards
1 furlong = 40 rods
1 statute mile = 8 furlongs
1 statute mile = 5280 feet
1 nautical mile = 6080 1/4 ft
1 league = 3 miles
1 degree = 69 1/6 miles

Square Measure

1 sq foot = 144 sq inches
1 sq yard = 9 sq feet
1 sq rod = 30 1/4 sq yards
1 section (of land) = 1 mile sq
1 township = 6 miles sq (36 sq mi)
1 acre = 160 sq rods
1 acre = 43,560 sq ft
1 sq mile = 640 acres

Liquid Measure

1 pint = 4 gills
1 quart = 2 pints
1 gallon = 4 quarts
1 barrel = 31 1/2 gallons
1 hogshead = 2 bbl. (63 gal.)
1 tun = 252 gallons
1 barrel (petroleum) = 42 gallons

Dry Measure

2 pints = 1 quart = 67.2006 cu in.
8 quarts = 1 peck = 537.605 cu in.
4 pecks = 1 bushel = 2150.419 cu in.

Avoirdupois Weight*

(For other than drugs, gold, silver, etc.)

1 dram = 27.3437 grains
1 ounce = 16 drams
1 pound = 16 ounces
1 quarter = 25 pounds
1 cwt = 4 quarters
1 ton = 20 dwt
1 short ton = 2000 pounds
1 long ton = 2240 pounds
1 lb avdp = 7000 grains = 453.59 grams = 1.2153 lb troy

Troy Weight*

(For gold, silver, etc. only)

1 pennyweight = 24 grains
1 pound troy = 12 ounces troy = 240 dwts = 5760 grains
1 oz troy = 20 pennyweights

Apothecaries' Weight*

1 scruple (s. ap) = 20 grains
1 dram apoth (dr ap) = 3 scruples
1 ounce apoth (oz ap) = 8 drams apoth
1 pound apoth (lb ap) = 12 ounces apoth = 96 drams apoth = 288 scruples = 5760 grains

---

* The "grain" is the same in avoirdupois, troy, and apothecaries' weight.

METRIC EQUIVALENTS

(Based on National Bureau of Standards)

Length

Cm = 0.3937 in.
Meter = 3.2808 ft
Meter = 1.0936 yd
Km = 0.6214 mile
In. = 2.5400 cm
Ft = 0.3048 m
Yd = 0.9144 m
Mile = 1.6093 km

Area

Sq cm = 0.1550 sq in.
Sq m = 10.7639 sq ft
Sq m = 1.1960 sq yd
Hectare = 2.4710 acres
Sq km = 0.3861 sq mile
Sq in. = 6.4516 sq cm
Sq ft = 0.0929 sq m
Sq yd = 0.8361 sq m
Acre = 0.4047 hectare
Sq mile = 2.5900 sq km

Volume

Cu cm = 0.0610 cu in.
Cu m = 35.3145 cu ft
Cu m = 1.3079 cu yd
Cu in. = 16.3872 cu cm
Cu ft = 0.0283 cu m
Cu yd = 0.7646 cu m

Capacity

Liter = 61.0250 cu in.
Liter = 0.0353 cu ft
Liter = 0.2642 gal. (U. S.)
Liter = 0.0284 bu (U. S.)
Liter = { 1000.027 cu cm
1.0567 qt (liquid) or 0.9081 qt (dry)
2.2046 lb of pure water at 4 C = 1 kg }
Cu in. = 0.0164 liter
Cu ft = 28.3162 liters
Gal. = 3.7853 liters
Bu = 35.2383 liters

Weight

Gram = 15.4324 grains
Gram = 0.0353 oz avdp
Kg = 2.2046 lb avdp
Kg = 0.0011 ton (sht)
Ton (met.) = 1.1023 ton (sht)
Ton (met.) = 0.9842 ton (lg)
Grain = 0.0648 g
Oz avdp = 28.3495 g
Lb avdp = 0.4536 kg
Ton (sht) = 907.1848 kg
Ton (sht) = 0.9072 ton (met.)
Ton (lg) = 1.0160 ton (met.)

Pressure

1 kg per sq cm = 14.223 lb per sq in.
1 lb per sq in. = 0.0703 kg per sq cm
1 kg per sq m = 0.2048 lb per sq ft
1 lb per sq ft = 4.8824 kg per sq m
1 kg per sq cm = 0.9678 normal atmosphere
1 normal atmosphere = { 1.0332 kg per sq cm
1.0133 bars
14.696 lb per sq in. }

DECIMAL AND METRIC EQUIVALENTS
OF FRACTIONS OF AN INCH

Inch				Inch				Inch			
Fraction		Decimal	Millimeters	Fraction		Decimal	Millimeters	Fraction		Decimal	Millimeters
1/64	=	.015625	.397	23/64	=	.359375	9.128	11/16	=	.6875	17.46
1/32	=	.03125	.794	3/8	=	.375	9.525	45/64	=	.703125	17.86
3/64	=	.046875	1.191	25/64	=	.390625	9.922	23/32	=	.71875	18.26
1/16	=	.0625	1.588	13/32	=	.40625	10.32	47/64	=	.734375	18.65
5/64	=	.078125	1.984	27/64	=	.421875	10.72	3/4	=	.75	19.05
3/32	=	.09375	2.381	7/16	=	.4375	11.11	49/64	=	.765625	19.45
7/64	=	.109375	2.778	29/64	=	.453125	11.51	25/32	=	.78125	19.84
1/8	=	.125	3.175	15/32	=	.46875	11.91	51/64	=	.796875	20.24
9/64	=	.140625	3.572	31/64	=	.484375	12.30	13/16	=	.8125	20.64
5/32	=	.15625	3.969	1/2	=	.5	12.70	53/64	=	.828125	21.03
11/64	=	.171875	4.366								
3/16	=	.1875	4.763	33/64	=	.515625	13.10	27/32	=	.84375	21.43
13/64	=	.203125	5.159	17/32	=	.53125	13.49	55/64	=	.859375	21.83
7/32	=	.21875	5.556	35/64	=	.546875	13.89	7/8	=	.875	22.23
15/64	=	.234375	5.953	9/16	=	.5625	14.29	57/64	=	.890625	22.62
1/4	=	.25	6.350	37/64	=	.578125	14.68	29/32	=	.90625	23.02
17/64	=	.265625	6.747	19/32	=	.59375	15.08	59/64	=	.921875	23.42
9/32	=	.28125	7.144	39/64	=	.609375	15.48	15/16	=	.9375	23.81
19/64	=	.296875	7.541	5/8	=	.625	15.88	61/64	=	.953125	24.21
5/16	=	.3125	7.938	41/64	=	.640625	16.27	31/32	=	.96875	24.61
21/64	=	.328125	8.334	21/32	=	.65625	16.67	63/64	=	.984375	25.00
11/32	=	.34375	8.731	43/64	=	.671875	17.06	1	=	1.0	25.40

METRIC EQUIVALENTS OF INCHES AND FRACTIONS OF AN INCH
IN CENTIMETERS

Inches	Fractions															
	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
0	0	.159	.318	.476	.635	.794	.953	1.111	1.270	1.429	1.588	1.746	1.905	2.064	2.223	2.381
1	2.54	2.70	2.86	3.02	3.18	3.33	3.49	3.65	3.81	3.97	4.13	4.29	4.45	4.60	4.76	4.92
2	5.08	5.24	5.40	5.56	5.72	5.87	6.03	6.19	6.35	6.51	6.67	6.83	6.99	7.14	7.30	7.46
3	7.62	7.78	7.94	8.10	8.26	8.41	8.57	8.73	8.89	9.05	9.21	9.37	9.53	9.68	9.84	10.00
4	10.16	10.32	10.48	10.64	10.80	10.95	11.11	11.27	11.43	11.59	11.75	11.91	12.07	12.22	12.38	12.54
5	12.70	12.86	13.02	13.18	13.34	13.49	13.65	13.81	13.97	14.13	14.29	14.45	14.61	14.76	14.92	15.08
6	15.24	15.40	15.56	15.72	15.88	16.03	16.19	16.35	16.51	16.67	16.83	16.99	17.15	17.30	17.46	17.62
7	17.78	17.94	18.10	18.26	18.42	18.57	18.73	18.89	19.05	19.21	19.37	19.53	19.69	19.84	20.00	20.16
8	20.32	20.48	20.64	20.80	20.96	21.11	21.27	21.43	21.59	21.75	21.91	22.07	22.23	22.38	22.54	22.70
9	22.86	23.02	23.18	23.34	23.50	23.65	23.81	23.97	24.13	24.29	24.45	24.61	24.77	24.92	25.08	25.2.4
10	25.40	25.56	25.72	25.88	26.04	26.19	26.35	26.51	26.67	26.83	26.99	27.15	27.31	27.46	27.62	27.7.8
11	27.94	28.10	28.26	28.42	28.58	28.73	28.89	29.05	29.21	29.37	29.53	29.69	29.85	30.00	30.16	30.32
12	30.48	30.64	30.80	30.96	31.12	31.27	31.43	31.59	31.75	31.91	32.07	32.23	32.39	32.54	32.70	32.86

EQUIVALENTS OF INCHES AND FRACTIONS OF AN INCH
IN DECIMALS OF A FOOT

Inches	Fractions															
	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
0	.0	.0052	.0104	.0156	.0208	.0260	.0312	.0365	.0417	.0469	.0521	.0573	.0625	.0677	.0729	.0781
1	.0833	.0885	.0938	.0990	.1042	.1094	.1146	.1198	.1250	.1302	.1354	.1406	.1458	.1510	.1562	.1615
2	.1667	.1719	.1771	.1823	.1875	.1927	.1979	.2031	.2083	.2135	.2188	.2240	.2292	.2344	.2396	.2448
3	.2500	.2552	.2604	.2656	.2708	.2760	.2812	.2865	.2917	.2969	.3021	.3073	.3125	.3177	.3229	.3281
4	.3333	.3385	.3437	.3490	.3542	.3594	.3646	.3698	.3750	.3802	.3854	.3906	.3958	.4010	.4062	.4115
5	.4167	.4219	.4271	.4323	.4375	.4427	.4479	.4531	.4583	.4635	.4688	.4740	.4792	.4844	.4896	.4948
6	.5000	.5052	.5104	.5156	.5208	.5260	.5312	.5365	.5417	.5469	.5521	.5573	.5625	.5677	.5729	.5781
7	.5833	.5885	.5937	.5990	.6042	.6094	.6146	.6198	.6250	.6302	.6354	.6406	.6458	.6510	.6562	.6615
8	.6667	.6719	.6771	.6823	.6875	.6927	.6979	.7031	.7083	.7135	.7188	.7240	.7292	.7344	.7396	.7448
9	.7500	.7552	.7604	.7656	.7708	.7760	.7812	.7865	.7917	.7969	.8021	.8073	.8125	.8177	.8229	.8281
10	.8333	.8385	.8437	.8490	.8542	.8594	.8646	.8698	.8750	.8802	.8854	.8906	.8958	.9010	.9062	.9115
11	.9167	.9219	.9271	.9323	.9375	.9427	.9479	.9531	.9583	.9635	.9688	.9740	.9792	.9844	.9896	.9948
12	1.0000	1.0052	1.0104	1.0156	1.0208	1.0260	1.0312	1.0365	1.0417	1.0469	1.0521	1.0573	1.0625	1.0677	1.0729	1.0781

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